4150 Area Velocity Flow Logger

Installation and Operation Guide



TELEDYNE ISCO
A Teledyne Technologies Company

Part # 60-3243-143 of Assembly # 60-3244-074
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Foreword

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Teledyne Isco recommends that you read this manual completely before placing the equipment in service.

Although Teledyne Isco designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If the problem persists, call or e-mail the Teledyne Isco Technical Service Department for assistance. Simple difficulties can often be diagnosed over the phone.

If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by the Customer Service Department, including the use of the **Return Authorization Number** specified. **Be sure to include a note describing the malfunction.** This will aid in the prompt repair and return of the equipment.

Teledyne Isco welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Teledyne Isco is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

Contact Information

Customer Service

Phone:	(800) 228-4373	(USA, Canada, Mexico)
	(402) 464-0231	(Outside North America)
Fax:	(402) 465-3022	
Email:	IscoCSR@teledyne.com	

Technical Support

Phone:	(800) 775-2965	(Analytical)
	(866) 298-6174	(Samplers and Flow Meters)
Email:	IscoService@teledyne.com	
Return equipment to:	4700 Superior Street, Lincoln, NE 68504-1398	

Other Correspondence

Mail to:	P.O. Box 82531, Lincoln, NE 68501-2531
Email:	IscoInfo@teledyne.com
Web site:	www.isco.com

Revised March 17, 2009

Before installing, operating, or maintaining this equipment, it is imperative that all hazards and preventive measures are fully understood.

Hazard Severity Levels

This manual applies *Hazard Severity Levels* to the safety alerts, These three levels are described in the sample alerts below.

⚠ CAUTION

Cautions identify a potential hazard, which if not avoided, may result in minor or moderate injury. This category can also warn you of unsafe practices, or conditions that may cause property damage.

⚠ WARNING

Warnings identify a potentially hazardous condition, which if not avoided, could result in death or serious injury.

⚠ DANGER

DANGER – limited to the most extreme situations to identify an imminent hazard, which if not avoided, will result in death or serious injury.

Hazard Symbols

The equipment and this manual use symbols used to warn of hazards. The symbols are explained below.

Hazard Symbols	
Warnings and Cautions	
	The exclamation point within the triangle is a warning sign alerting you of important instructions in the instrument's technical reference manual.
	The lightning flash and arrowhead within the triangle is a warning sign alerting you of "dangerous voltage" inside the product.
Symboles de sécurité	
	Ce symbole signale l'existence d'instructions importantes relatives au produit dans ce manuel.
	Ce symbole signale la présence d'un danger d'électocution.
Warnungen und Vorsichtshinweise	
	Das Ausrufezeichen in Dreieck ist ein Warnzeichen, das Sie darauf aufmerksam macht, daß wichtige Anleitungen zu diesem Handbuch gehören.
	Der gepfeilte Blitz im Dreieck ist ein Warnzeichen, das Sei vor "gefährlichen Spannungen" im Inneren des Produkts warnt.
Advertencias y Precauciones	
	Esta señal le advierte sobre la importancia de las instrucciones del manual que acompañan a este producto.
	Esta señal alerta sobre la presencia de alto voltaje en el interior del producto.

4150 Flow Logger

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4150 Flow Logger

Section 1 Introduction

The 4150 Flow Logger is a flow-monitoring instrument that directly measures the average velocity and level, and calculates the flow rate of an open-channel flow stream. The 4150 consists of a portable case and a detachable velocity sensor.

Using technology based on the Doppler effect, the velocity sensor directly detects the average velocity of a stream as the flow moves up or downstream. The sensor, equipped with an internal pressure transducer, also measures the level of the flow stream. It can be installed in round, rectangular, trapezoidal, and U-channel pipes. It does not require a primary device, such as a weir or flume, to obtain readings.

The 4150 depends on an IBM-compatible computer running FLOWLINK, Teledyne Isco's flow-data management software, for programming and calibration. To program the 4150, simply connect it to a computer running FLOWLINK and program the 4150 from the computer's keyboard. You can enter settings for sampler pacing, and sampler-enable controls, or set up the 4150's internal memory to store data. FLOWLINK also retrieves stored data and converts level data to flow data with conversion formulas or tables.

1.1 Features

Sampler Controls – The 4150 paces samplers for flow-weighted sampling. It has a number of sampler-enable controls that start and stop the sampler when the 4150 detects programmed velocity, level, flow rate, or rainfall measurements.

Internal Memory for Data Storage – The 4150 stores velocity, level, flow-rate, and sample event data in 230 kilobytes of non-volatile, battery-backed RAM (Random Access Memory).

Low Power Consumption – Two fully-charged 6-volt lantern batteries will power a 4150, programmed to take readings at 15-minute intervals, for approximately 3 months without recharging or replacement. The 947 Lead-Acid Battery has a capacity of approximately 45 days.

Variety of Power Sources – Power the 4150 with two 6-volt lantern batteries, an Isco 947 Lead-Acid Battery, the Isco 954 Solar Panel Battery Charger, or an Isco 946 Lead-Acid Battery. An Isco sampler can also power a 4150.

Battery Protection and Battery Life Monitoring – The 4150 monitors battery use for all battery types and reports the remaining battery life to FLOWLINK. The 4150 shuts down before a battery discharges completely, protecting lead-acid batteries and the integrity of your data.

Optional 4200T Modem – A factory-installed option, the 4200T Modem is a full duplex, auto-answer modem with dial-out capabilities and a speech synthesizer. It lets FLOWLINK exchange data with the logger over standard voice-grade telephone lines and program it to deliver voice messages to as many as five telephone numbers when it detects user-definable alarm conditions.

> ☑ ***Note***
>
> The modem is disabled when an interrogator cable is connected to the flow logger's Interrogator port. It cannot receive incoming calls, and the alarm dialout will be rendered inoperable, while this cable is connected. **Disconnect the interrogator cable in order to use the 4200T Modem.**

Flash Memory for Easy Software Upgrades – As Teledyne Isco adds software features to the 4150, upgrade your unit by connecting a computer and uploading the new software.



Figure 1-1 4150 Flow Logger and Standard Area Velocity sensor

1.2 Compatible Isco Equipment

The 4150 Flow Logger is compatible with the following Isco equipment:

- 3700 Series Samplers
- 6700 Series Samplers
- GLS and Glacier Samplers
- Isco 674 Rain Gauge
- Isco Solar Panel

Teledyne Isco provides cables to connect the 4150 Flow Logger to samplers and the 674 Rain Gauge.

1.3 What is in This Manual?

This manual is an installation and maintenance manual for the 4150 Flow Logger and the velocity sensor. It contains:

- A brief description of the 4150's features
- Installation instructions for the 4150 and for the sensors
- Maintenance guidelines
- Technical specifications for the 4150 and the sensors

1.4 How to Get Help

For service information and technical support, contact Teledyne Isco's Environmental Product Specialists.

Telephone:

(866) 298-6174

E-mail:

IscoService@teledyne.com

For general questions and ordering information, contact Teledyne Isco's Customer Service Department.

Teledyne Isco, Inc.
P.O. Box 82531
Lincoln, NE 68501

E-mail:

IscoInfo@teledyne.com

Telephone:

Within U.S.A (toll free): (800) 228-4373
Outside U.S.A.: (402) 464-0231
FAX: (402) 465-3022

1.5 Repairing Your Flow Logger

Because of the nature of its microprocessor-based circuitry, the flow logger has no user-serviceable parts. If you think your flow logger requires repair, contact Customer Service for information on returning it to the factory.

1.6 Technical Specifications

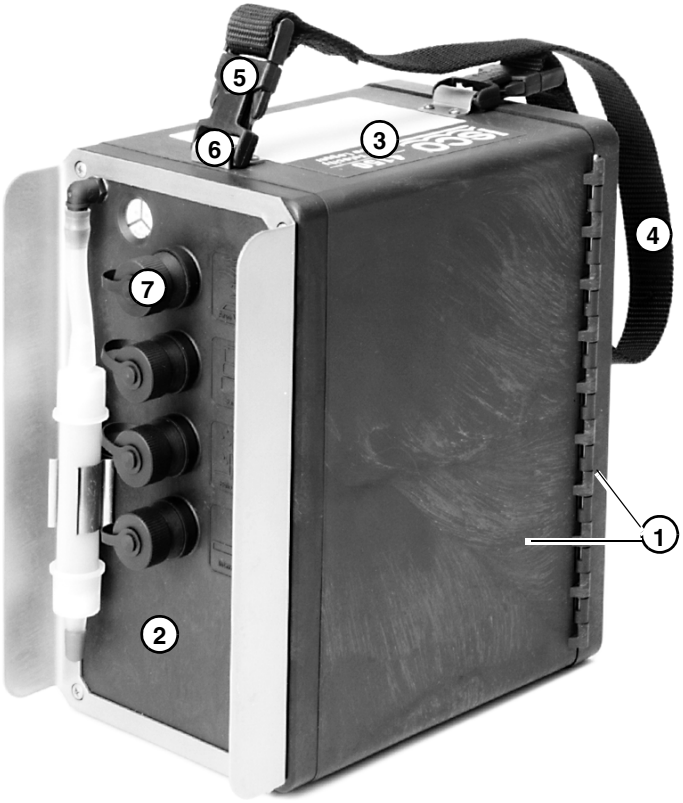


Figure 1-2 4150 Replaceable Parts

1. **Case and battery compartment door:** polystyrene.
2. **Connector panel:** Noryl
3. **Labels:** polyester
4. **Strap:** nylon
5. **Strap latches:** acetyl plastic
6. **Strap-latch retainer:** stainless steel
7. **Connector cap:** (acetyl plastic)
8. **Suspension hook:** stainless steel (not shown)

Table 1-1 4150 Flow Logger Technical Specifications

Size	10.5 x 9.0 x 6.0 inches (26.7 x 22.9 x 15.2 centimeters)
Weight	8 pounds (3.6 kilograms), without batteries
Operating Temperature	0• to 140• F (-18• to 60• C)
Storage Temperature	-40• to 140• F (-40• to 60• C)
Enclosure	Self-certified NEMA 4X, 6
Power	Two 6-volt alkaline lantern batteries, or one 12-volt Isco 947 Lead-Acid Battery
Alkaline Battery Life	3 months with minimum level-reading intervals of 15 minutes

Table 1-2 Standard/Extended Range AV Probe Technical Specifications	
Sensor Size	1 3/16" High x 1 5/8" Wide x 6 5/8" Long (3.0 x 4.1 x 16.8 cm)
Sensor Weight	Standard sensor: 2.1 pounds (0.96 kilograms) (includes 25-foot cable and connector) Extended range sensor: 3.9 pounds (1.8 kilograms) (includes 50-foot cable and connector)
Wetted Sensor Material	Polybutadiene-based polyurethane, stainless steel
Cable Length	Standard sensor: 25 feet (7.6 meters) Extended range sensor: 50 feet (15.2 meters)
Maximum Distance: (Between area velocity sensor and Flow Logger)	Standard Sensor: 75 feet (22.8 meters) with optional extension cables. Extended Range Sensor: 100 feet (30.5 meters) with optional extension cables. The distance can be extended up to 1000 feet (304.8 meters) with the optional Quick Disconnect Box.
Cable Material	PVC (polyvinyl chloride), CPVC (chlorinated polyvinyl chloride)
Operating Temperature	32• to 160• F (0• to 71• C)
Storage Temperature	-40• to 160• F (-40• to 71• C)
Level Specifications	
Level-Measurement Range	Standard sensor: 0.05 to 10.0 feet (0.015 to 3.05 meters) Extended range sensor: 0.05 to 30.0 feet (0.015 to 9.14 meters)
Maximum Allowable Level	Standard sensor: 20.0 feet (6.10 meters) Extended range sensor: 40.0 feet (12.19 meters)
Level Measurement Accuracy	Standard sensor (25• C): 0.033 to 5.0 ft: ± 0.008 ft/ft (0.01 to 1.52 m: ± 0.008 m/m) >5.0 ft: ± 0.012 ft/ft (>1.52 m: ± 0.012 m/m) Extended range sensor (25• C): Head change of 0.05 to 15.0 feet (0.015 to 4.57 meter): ± 0.03 foot (0.009 meter) Head change of 0.05 to 21.0 feet (0.015 to 6.40 meter): ± 0.09 foot (0.027 meter) Head change of 0.05 to 30.0 feet (0.015 to 9.14 meter): ± 0.30 foot (0.091 meter) (*Specifications include nonlinearity, repeatability, and hysteresis, but do not include a temperature coefficient.*)
Compensated-Temperature Range	32• to 100• F (0• to 38•C)
Temperature Error (over-compensated-temperature range, per degree of temperature change)	Standard sensor: 0.05 to 4.0 ft (0.015 to 1.22 m): ± 0.005 ft/•F (± 0.0027 m/•C) 4.0 to 10.0 ft (1.22 to 3.05 m): ± 0.007 ft/•F (± 0.0038 m/•C) Extended range sensor: 0.05 to 30.0 ft (0.015 to 9.14 m): ± 0.008 ft/•F (± 0.0044 m/•C)

Table 1-2 Standard/Extended Range AV Probe Technical Specifications (Continued)	
Velocity Measurement	
Minimum Depth for Velocity Measurement	2, 3, 4 inches (50, 75, 100 mm) Selected during programming
Range	-5 to +20 feet per second (-1.5 to +6.1 meters per second)
Accuracy	-5 to +5 ft/s (-1.5 to +1.5 m/s): ± 0.1 ft/s (± 0.03 m/s) 5 to 20 ft/s (1.5 to +6.1 m/s): 2% of reading
Resolution	± 0.024 feet per second (± 0.0073 meters per second)
Frequency	500KHz
Nose Angle	35 degrees from horizontal

Table 1-3 Low Profile AV Probe Technical Specifications	
Weight	2.1 lbs (.95 kg) including cable and connector
Sensor Dimensions	Length: 6.00 inches (15.2 cm) Width: 1.31 inches (3.3 cm) Height: 0.75 inches (1.9 cm)
Nose Angle	110° from horizontal
Wetted Sensor Material	Epoxy, chlorinated polyvinyl chloride (CPVC), Stainless-steel
Cable Material	Polyvinyl chloride (PVC) Chlorinated polyvinyl chloride (CPVC)
Cable Length	25 ft (7.6 m)
Maximum Distance (between sensor and module)	75 ft (22.8 m) with optional extension cables. The distance can be extended up to 1000 ft (300 m) with the optional Quick Disconnect Box.
Operating Temperature	32° to 122°F (0° to 50°C)
Storage Temperature	-40° to 160°F (-40° to 71°)
Level Specifications	
Level Measurement Range	0.033 to 10.0 ft (0.01 to 3.05 m)
Maximum Allowable level	20 ft (6.1 m)
Level Measurement Accuracy	0.033 to 5.0 ft: ± 0.008 ft/ft (0.01 to 1.52 m: ± 0.008 m/m) >5.0 ft: ± 0.012 ft/ft (>1.52 m: ± 0.012 m/m) Accuracy per foot of change from calibrated depth @77°F (25°C). Includes non-linearity and hysteresis.
Temperature Coefficient	± 0.0023 ft/°F (± 0.0013 m/°C) Maximum error within operating temperature range at zero pressure (per degree of change from calibration temperature).
Maximum Long-term Drift	0.033 ft (± 0.010 m)

Table 1-3 Low Profile AV Probe Technical Specifications (Continued)

Velocity Measurement	
Velocity Measurement Method	Doppler Ultrasonic
Frequency	500 kHz
Transmission Angle	20° from horizontal
Typical minimum depth for velocity measurement	1 inch (25 mm)
Range	-5 to +20 ft/s (-1.5 to +6.1 m/s)
Velocity Accuracy	-5 to +5 ft/s (-1.5 to +1.5 m/s): ± 0.1 ft/s (± 0.03 m/s) 5 to 20 ft/s (1.5 to 6.1 m/s): 2% of reading Velocity accuracy for a uniform velocity profile in water with a speed-of-sound of 4850 ft/s.

4150 Flow Logger

Section 2 Programming and Installation

2.1 Programming the 4150

To program the 4150, connect it to a computer and enter the program with Flowlink. Flowlink provides all programming instructions for the flow logger. For a summary of Flowlink's functions, refer to Table 2-1. More information about programming the flow logger is in the *Flowlink Help*.

2.1.1 About the 4150's Memory

The flow logger's memory contains 230 kilobytes of nonvolatile, battery-backed RAM (Random Access Memory) which Flowlink divides into storage areas called partitions. Although the amount of data stored in each partition varies according to the type of data and the partition size, 230 kilobytes divided into three equally sized partitions stores:

- More than 400 days of level, flow-rate, velocity, or rainfall data at 15-minute intervals
- 5,000 sample-event readings

2.1.2 Sampler Enabling and Sampler Pacing

The 4150 offers two types of sampler control: sampler enable and sampler pacing. A 4150 programmed to enable or disable a sampler compares level, flow, time, or rainfall measurements to a set point, usually the reading measurement at which the 4150 is to enable or disable the sampler. Thus, a set point can be:

- At a specific time and date
- When the flow stream's level, velocity, or flow rate passes a set point (for example, a level measurement of 0.3 foot)
- When the amount of rainfall exceeds a set point (1 inch of rain collected in 30 minutes, for instance)

Although you can program the 4150 to enable the sampler on a single data type's set point, you can also combine most data types with three logical operators: AND, OR, and NOT. Refer to Table 2-2. Using the operators, a flow logger can enable a sampler when reading two set points (level AND rainfall) or either set point (level OR rainfall).

The second type of sampler control, sampler pacing, determines how often the sampler will take a sample. The flow logger offers both flow pacing and trigger pacing.

To learn more about flow logger memory, sampler enabling, and sampler pacing, refer to the *Flowlink Help*.

Table 2-1 Flowlink Tasks

Programming Instructions	Status Information	Data Management
• Sampler pacing	• Battery life	• Data retrieval
• Sampler enable controls	• Flow-stream status: totalized flow current level flow rate	• Reports
• Memory setup: number of partitions type of data interval between readings	• Sampler enabled or disabled	• Graphs • Data editing
• Level calibration	• Memory status	• Import/export data in ASCII format
• Level-to-flow conversion	• 4150 clock • 4150 software version	

Table 2-2 Sampler-Enable Data Types and Logical Operators

Data Type or Condition	Set Point	Logical Commands
Always ON	None (The flow logger will use this condition unless you specify otherwise.)	No
Always OFF	None	No
Level	Level reading	Yes
Flow	Flow-rate	Yes
Time	Start time	Yes
Rainfall	Total rainfall measured in a specific period	Yes
Velocity	Velocity reading	Yes

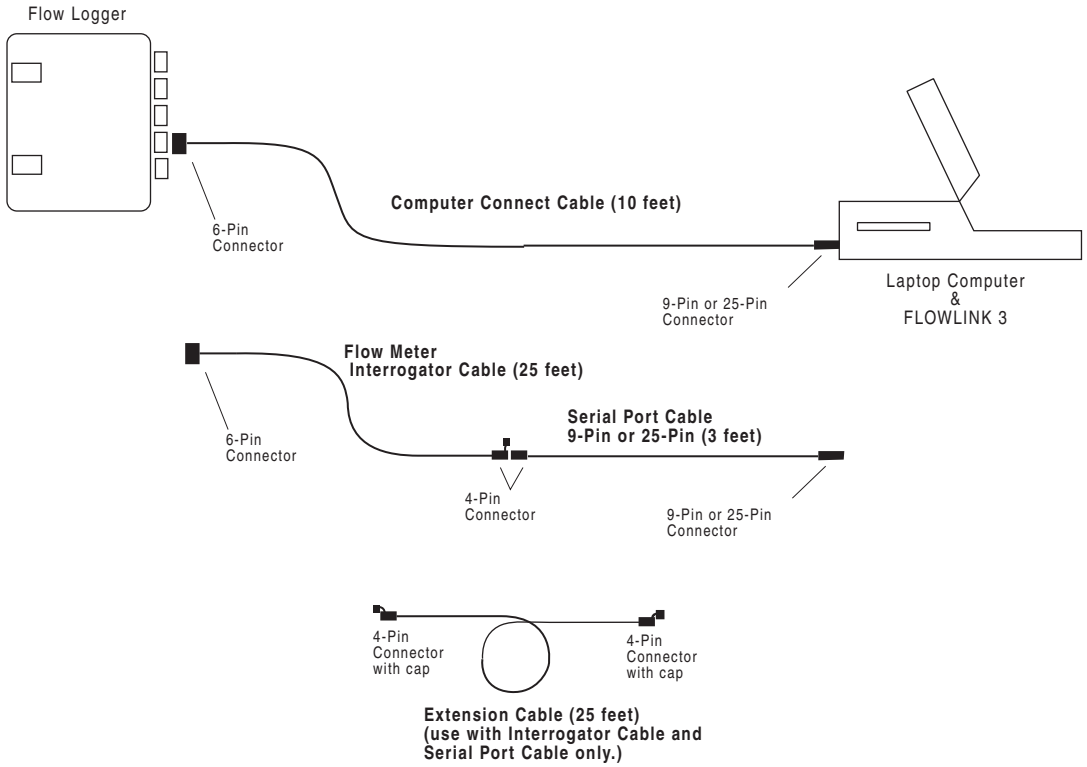
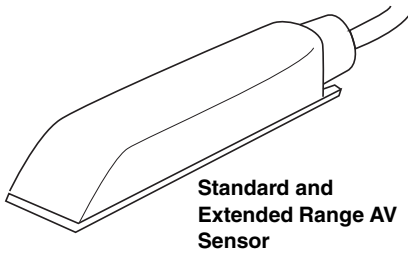
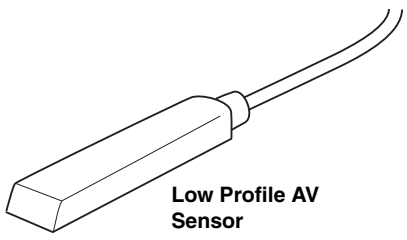


Figure 2-1 Programming the 4150

2.2 To Install the 4150 Flow Logger, You Need…



Standard and Extended Range AV Sensor



Low Profile AV Sensor

- 4150 Flow Logger
- Power source: two 6-volt alkaline batteries or an Isco 947 Lead-Acid Battery. (Note: Use only *alkaline* lantern batteries; nonalkaline batteries cannot produce sufficient power under load.) Other power sources are available; see About Power Sources on Page 2-15.
- Area Velocity sensor. Three types are available:
  - A **Standard-Range** sensor that has a 25 ft (7.6 m) cable and a pressure transducer with a 10 ft (3.05 m) level measurement range.
  - An **Extended-Range** sensor that has a 50 ft (15.2 m) cable and a pressure transducer with a 30 ft (9.14 m) level measurement range.
  - A **Low Profile** sensor that has a 25 ft (7.6 m) cable and a pressure transducer with a 10 ft (3.05 m) level measurement range. Its smaller size allows velocity measurements at very low liquid depths.
- Mounting hardware for the sensor. You may also need a stud gun to attach the mounting hardware to the wall of the pipe or channel.

- *The 4150 Flow Logger Instruction Manual* (this manual).
- *The Isco Mounting Rings Instruction Manual* (60-3203-061).
- Optional: 25 ft (7.6 m) Area Velocity sensor Extension Cable.
- Optional: Custom-length cable (to 1,000 feet) with an Isco Area Velocity Quick Disconnect Box.

2.3 To Program and Calibrate the 4150, You Need…

- Isco 9-pin or 25-pin Computer Connect Cable
- IBM PC or compatible computer. You can use a desktop or laptop model.
- Teledyne Isco's Flowlink software and the *Flowlink Help.*

2.4 Installation Locations

You can install the 4150 Flow Logger in nearly any location. A removable handle at the top of the 4150 case suspends the unit from a manhole ladder or other support.

Teledyne Isco provides installation hardware to install the velocity sensor in:

- Round pipes;
- U-channel pipes;
- Rectangular and trapezoidal channels.

The area velocity sensor does not require a weir or flume to obtain readings.

⚠ WARNING

The 4150 Flow Logger has not been approved for use in hazardous locations as defined by the National Electrical Code. Before installing any device in a dangerous location, review safety precautions. (See Appendix B General Safety Procedures.) Check applicable guidelines, codes, and regulations of federal, state, city, and county agencies.

2.5 Installation Checklist

Before installing the 4150:

1. Check the condition of the desiccators. (See Section 3.2 for more information.)
2. Install a fresh battery. You can use:
   - Two 6-volt alkaline lantern batteries. Lantern batteries are available from Teledyne Isco or local hardware stores. (Note: Use only *alkaline* lantern batteries; nonalkaline batteries cannot produce sufficient power under load.)
   - Isco 947 Lead-Acid Battery. This battery, built especially for the flow logger, is available only from Teledyne Isco.
   - Isco 946 Lead-Acid Battery recharged on-site with an Isco 954 Solar Panel.

- Power from an Isco sampler. The 4150 obtains power from the sampler through the cable connecting the 4150 and the sampler.
- A 12-volt DC marine battery can also be used as a power source for the 4150. These batteries require adapter cables and must be mounted outside the 4150's case. *Do not use external power sources that produce more than 13 volts. Excessive voltage will blow the internal fuses, and may cause more serious damage.*

3. Connect a computer to the 4150 and use Flowlink to:
   - Set up the 4150's memory, specifying the type of data you want to store
   - Set up the sampler-enable controls you want to use Enter the flow conversion settings
   - Check the remaining battery life (alkaline lantern or Isco lead-acid batteries, only).

At the installation site:

4. Install the Area Velocity sensor in the channel with a mounting ring.

   Be sure you have the correct Isco mounting ring. Although your initial order will include the mounting hardware you'll need, you may need a variety of mounting rings if you move the 4150 from site to site. (See *The Isco Mounting Rings Instruction Manual*.

   You may also need a stud gun to attach the ring to the wall of the pipe or channel. Install the sensor and ring upstream from the outfall of the pipe or invert.

5. Install the 4150. Use the suspension handle and hook to hang the 4150 from a manhole ladder or other support. See Figure 2-2.
6. Connect the Area Velocity sensor's cable to the 4150.
7. Connect external instruments (rain gauge, sampler, etc.), if used.
8. Connect a laptop computer to the 4150, calibrate the sensor's level measurement and program the 4150.



Figure 2-2 Suspending the 4150 (suspension handles may vary)

2.6 About the Area Velocity Sensor

The Isco Area Velocity Sensor uses the Doppler effect to directly measure the average velocity of a flow stream. The Doppler effect is a phenomenon in which the relative motion between a wave transmitter/receiver and particles reflecting the waves causes a change in the observed frequency of the wave. As the transmitter/receiver and the wave-reflecting particles move away from each other, the frequency decreases. The frequency increases as they approach each other. Note that the particles can be any reflective object suspended in the water: waste matter or even microscopic air bubbles.

Although the Doppler effect occurs with any type of wave — sound, light, or radio waves — the flow logger uses ultrasonic waves transmitted and received by a pair of ultrasonic transducers. One transducer transmits an ultrasonic signal into the moving flow stream. The flow stream reflects some of the signal back to the receiving transducer, which observes a shift in the signal's frequency. The difference between the transmitted frequency and the received frequency is proportional to the velocity of the flow stream. Because the transducers detect both increases

and decreases in frequency, the sensor detects the velocity of forward (toward the sensor) and reverse (away from the sensor) flows.

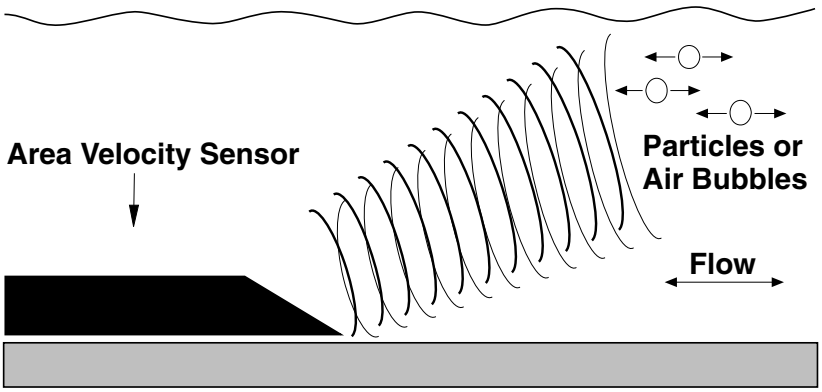


Figure 2-3 Area Velocity sensor Operation

The 4150 measures velocity as long as the flow stream:

- Contains sufficient number and dispersal of suspended particles to reflect the sensor's signal.
- Has sufficient velocity to keep particles suspended in the stream.

A typical sewer should have more than enough particles for a 4150 to measure velocity. However, if you can see the bottom of the channel, the flow stream may not contain enough reflective particles for the sensor to obtain reliable readings. If the stream is very slow, it may not be able to hold particles in suspension. The 4150 records an Error Code 248 in memory when it cannot detect enough reflections from the stream. These codes appear in the reports produced by Flowlink. You can also check the diagnostics window in Flowlink's status window to see the Signal Strength reported by the flow logger. Signal strength indicates the relative number of particles in the stream; a low signal strength suggests that there are a low number of reflective particles. (See the *Flowlink Help* for information on error codes and diagnostics.)

If you question whether a 4150 would operate satisfactorily at a particular site, consider installing the flow logger for a short period of time to evaluate its performance. Your sales representative or Teledyne Isco's Customer Service department can help you select the Isco flow measurement instrument that will give you the best results for your application.

2.6.1 Level Measurement

The AV sensor consists of a molded body, also called a *probe*. In addition to the pair of ultrasonic transducers, the probe contains a differential pressure transducer that senses the hydrostatic pressure produced by the liquid above the sensor. The transducer converts pressure to analog signals and sends the signals to the 4150.

Because pressure is proportional to the level of the stream, the 4150 can convert the analog signals to level readings. The 4150 stores the level and velocity readings in memory. The level readings may be converted to flow rates when you retrieve the readings with Flowlink and a computer. Flowlink converts the level readings with level-to-flow-rate conversion formulas or tables, depending on the requirements of the site.

2.6.2 How Does the Pressure Transducer Work?

The AV sensor's pressure transducer senses pressure through a small stainless steel diaphragm that transfers pressure to a small piezo-resistive element. The outer face of the diaphragm is exposed to the flow stream through the ports at the rear of the sensor. The inner face is exposed, or referenced, to the atmosphere through the internal vent tube that runs the full length of the sensor's cable.

The outer face is subjected to the pressure exerted by both the liquid and the atmosphere while the inner face of the diaphragm is subjected only to atmospheric pressure. The difference between the pressures exerted on the diaphragm is the hydrostatic pressure.

2.6.3 Installation Considerations

By comparing the hydrostatic pressure to atmospheric pressure, the 4150 obtains a differential pressure measurement that is unaffected by changes in atmospheric pressure. But if the vent tube becomes blocked — because the cable is kinked or the tube fills with condensed water — the transducer's inner face is no longer exposed to atmospheric pressure and the readings become erroneous.

Proper installation prevents the cable from kinking, and a desiccant on the vent line prevents moisture from accumulating within the tube. The sensor connector contains a port to accept the vent tube at the end of the sensor cable. A tube on the inside of the 4150 continues the vent to the desiccant tube on the 4150's exterior.

Another consideration is the amount of silt in the flow stream. Silt build-up in front of the velocity sensor may temporarily hinder velocity measurement. Silt may accumulate when flow drops, but clears away again when the flow increases, enabling the 4150 to resume measuring velocity. While the sensor is covered with silt, the 4150 may store Error Code 248 to indicate that it was unable to detect enough reflections. To keep the sensor out of the silt, mount it off the bottom center of the channel. (See Obtaining Measurements for Calibration on Page 2-10.) If mounting the probe off-center, remember to enter the Zero Level Offset in the Site Setup window in Flowlink.

2.7 Installation in Pipes and Inverts

Before installing the sensor, consider the following points.

- Abusive handling will damage the pressure transducer inside the sensor. Although the velocity sensor will survive normal handling and installation, treat the sensor with reasonable care.
- Install the Standard and Extended Range AV Sensors in flow streams where the liquid covers the sensor. These sensors detect levels above approximately 0.05 foot (0.6 inch or 15 mm) and velocities in streams with a minimum depth of 2 to 4 inches (50-100 mm).
- Install the Low Profile AV Sensors in streams where the liquid covers the sensor. Low Profile Sensors detect levels above approximately 0.033 feet (0.4 inch or 1.0 cm) and typically can measure velocities in streams as low as 1 inch (25 mm). Streams that run consistently below 1 inch are not a good application for the 4150.
- When installing the sensor in a pipe or invert, position the sensor upstream from the outfall. For the most reliable readings, the sensor should be at the bottom center of the flow stream. Although the sensor is easiest to calibrate when located at the bottom of a stream, you can locate it at one side of larger pipes to prevent silt and debris from accumulating on the sensor. For additional information on calibration, see Obtaining Measurements for Calibration on Page 2-10 and the *Flowlink Help*.
- One of the advantages of using the velocity sensor is that it does not require a primary device to obtain readings. However, if you choose to install the sensor in a channel with a primary device, locate the sensor upstream or downstream from the device, not within the device.
- Primary devices (weirs or flumes) with constrictive throats change the velocity of the flow stream as the water moves through the device. To minimize the effect of the device on the stream's velocity, the sensor must be installed at point in the stream where the flow has normalized. Install the sensor at the head measuring point of the device only when you need level readings *only* and can afford to disregard the velocity readings.
- There is a 25-foot vented extension cable available for the 4150. Maximum total cable length (sensor cable plus extension cables) is 75 feet.

2.7.1 Obtaining Measurements for Calibration

To calibrate the 4150, you must have the flow logger connected to a computer running Flowlink, and, depending on the installation, you must take one or two measurements. When the sensor is installed at the bottom of a pipe, measure the level of the liquid. The level, L in Figure 2-10, is the distance from the surface of the stream to the bottom center of the pipe. Always measure the level in front of the mounting ring.

When the sensor is located on the side of the pipe, calibration requires two measurements: level and the depth of the sensor. To obtain the depth, measure from the bottom center of the sensor to the surface of the stream. Flowlink requires two entries for calibration: the level and the offset. The offset is defined as the vertical distance from the bottom of the pipe to the bottom center of the sensor (the location of the pressure transducer). Using the level and depth measurements, you can calculate the sensor's offset from the bottom of the stream: **O = L – D**. If the sensor is at the bottom center of the pipe, the offset is, of course, zero.

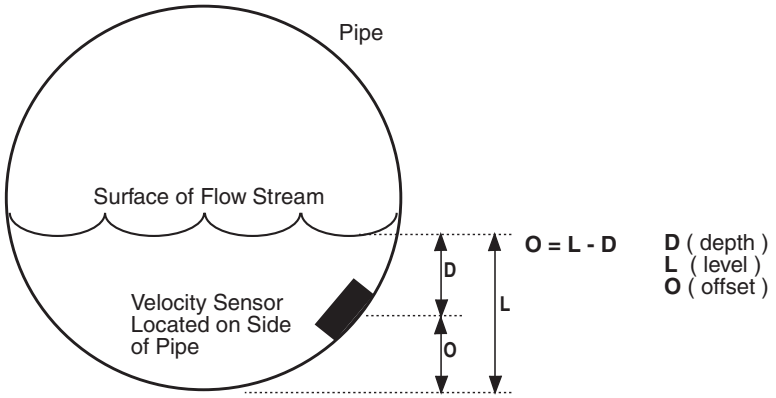


Figure 2-4 Calibration Measurements

2.7.2 Minimum Depth for Velocity Measurements

Standard and Extended Range Sensors – Three selections are available for the minimum depth for velocity measurements: 2, 3, or 4 inches (50, 75, or 100 mm). The Minimum Depth is the minimum amount of water above the bottom of the sensor that is required to obtain a velocity reading. This depth varies with the velocity of the flow stream; at higher velocities, the depth is greater.

When the level of the flow stream falls below the Minimum Depth, the flow meter approximates the velocity readings using velocity readings taken earlier, when depths were greater than the minimum. Under these conditions, the flow meter will not be able to detect the direction of the flow in the channel.

Determine the correct selection for the Minimum Depth by testing the flow meter for a period of time with the default selection: 3 inches. In most installations this will be the optimum selection. If, after examining the velocity data, you see a sharp decrease in velocity as the level readings approach 3 inches, increase the minimum depth to 4 inches. You can use the 2-inch option when the channel produces flows of very low velocity.

Low Profile AV Sensors – These sensors do not have a program selection for minimum depths. Low profile sensors attempt to measure velocity regardless of depth. Typically a low profile sensor provides error-free velocity readings to depths as low as 1 inch (25 mm).

> ☑ ***Note***
>
> The MINIMUM DEPTH setting will only appear if you are using a **standard** 10 ft or 30 ft AV probe. This setting will not appear if you are using a low profile AV probe. The standard probe cannot sense velocities below two inches of depth. Measurements below the minimum depth are approximations based on the velocity characteristics of the stream and previous measurements at other levels.

2.8 Rectangular and Trapezoidal Channels

A flat, anchored mounting plate is a common mounting choice for installing sensors in rectangular or trapezoidal channels. See the *Isco Mounting Rings Installation and Operation Guide* for more information.

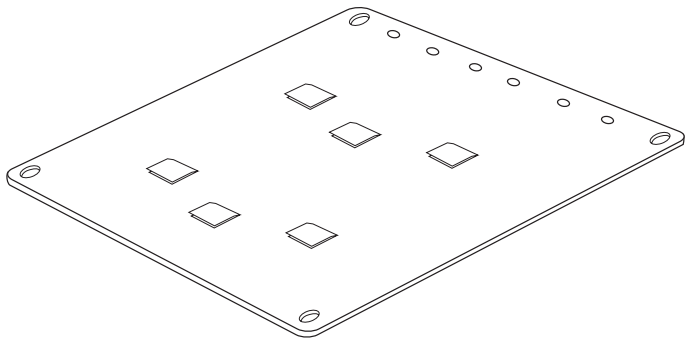


Figure 2-5 Isco Rectangular Mounting Plate

2.9 Mounting Rings for Circular Channels

Consult your Isco Mounting Rings Installation and Operation Guide for detailed hardware information.

The following sections describe sensor installation using the two options available for mounting the Sensor in pipes or round-bottomed flow streams. For pipes up to 15" (38.1 cm) in diameter, **stainless steel self-expanding mounting rings** (**Spring Rings**) are available. For pipes larger than 15" in diameter, Teledyne Isco offers the **Scissor Rings (Universal Mounting Rings)**. Area velocity sensors can also be installed using primary measuring devices.

2.9.1 Spring Rings

To install a spring ring, you compress the ring, slip it inside the pipe, and then allow it to spring out to contact the inside diameter of the pipe. The inherent outward spring force of the ring firmly secures it in place. A typical self-expanding mounting ring (with a probe mounted on it) is shown in Figure 2-6.

These mounting rings are available for use in pipes with inside diameters of 6" (15.2 cm), 8" (20.3 cm), 10" (25.4 cm), 12" (30.5 cm), and 15" (38.1 cm). The Teledyne Isco part numbers for the various size mounting rings available are listed in Appendix B. These part numbers include not only the ring, but also the miscellaneous hardware necessary to mount the sensor on the ring.

⚠ CAUTION

Always wear leather gloves when handling the rings (either type). The metal is finished, but there is still a possibility of cutting your hands on the edges.

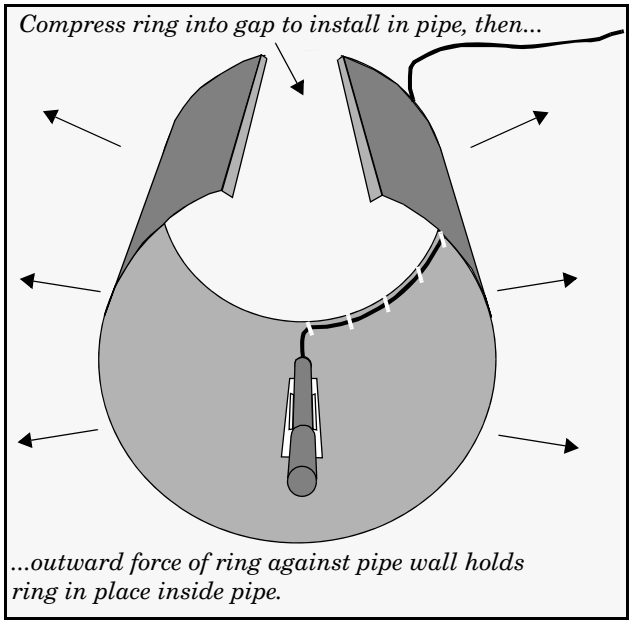


Figure 2-6 Sensor Installed on a Spring Ring

⚠ CAUTION

Make sure the slots on the sensor are completely pressed onto the tabs on the ring. This is particularly important where there is any possibility of reverse flows, or where flows are of high velocity. If the sensor is not fully pressed onto the mounting ring tabs, it might come loose in the stream, and could possibly be damaged or lost.

Completing the assembly

To complete the sensor-spring ring assembly procedure, attach the sensor cable to the downstream edge of the ring. Follow the cable routing shown in Figure 2-6. Other routing directions may affect measurement accuracy. The cable can actually create a stilling well downstream from the sensor, causing the level to

read low. Use the self-locking plastic ties supplied with the ring. Install the ring in the pipe by compressing it. Press inward on both sides and slide the ring into the pipe.

Route the sensor cable out of the stream and secure it in position by placing the ties through the holes in the mounting ring and then locking them around the cable, as shown. To prevent debris from catching on the cable, it is important to attach the cable to the mounting ring so it offers as little resistance to the flow as possible.

⚠ CAUTION

Make sure the sensor cable is securely fastened along the back (downstream) edge of the ring. Otherwise, the sensor may provide **inaccurate level readings** under conditions of high velocity.

Do not overtighten the plastic cable ties; they should be tightened just enough to secure the cable in place, without greatly indenting the cable. Overtightening the plastic ties may collapse the reference tube in the cable, blocking it.

The spring ring may need anchoring. Under conditions of high velocity (greater than 5 feet per second or 1.5 meters per second), the ring may not have sufficient outward spring force to maintain a tight fit inside the pipe. The ring may start to lift off the bottom of the pipe in a waving fashion, or may even be carried downstream.

This problem is more prevalent in the larger diameter pipes (10", 12", and 15", and in pipes with smooth inside surfaces, such as plastic pipes). If any of these conditions are present, or if movement of the mounting ring is detected or suspected, you must anchor the ring in place. You can do this by setting screws through the ring into the pipe, or by other appropriate means. If there is a problem with the smaller diameter rings, it may be sufficient to simply increase the outward spring force of the ring by bending it into a less round configuration.

2.9.2 Scissors Rings

For pipes larger than 15" in diameter, Teledyne Isco offers the adjustable Scissors Ring (also known as the Universal Mounting Ring). This device consists of two or more metal strips that lock together with tabs to form a single assembly. There is a base section where the sensors are mounted, one or more extension sections (usually), and a scissors section at the top that expands the entire assembly and tightens it inside the pipe. The scissors mechanism includes a long screw that increases the width as it is tightened.

The assembled rings fit pipe diameters from 16" to 80". Secure the unit in place by tightening the scissors mechanism with a $^5/_8$" socket wrench or other suitable tool. Ring sections are .040" thick

half-hard 301 stainless steel sheet. All other parts are also stainless steel, except for the plastic cable ties in the hardware kit.

Each extension, 1, 2, 3, and 4, adds 9.0", 21.5", 31.5", or 41.5", respectively, to the circumference of the ring. Used alone, the base section fits pipe that is approximately 16" to 18" in diameter. The 9.0" (the smallest) extension exists so that in larger pipe sizes, where large variations in circumference can occur, you can use one or two of these extensions to take up or remove slack, to bring the scissors mechanism into a position where it can be effectively tightened.

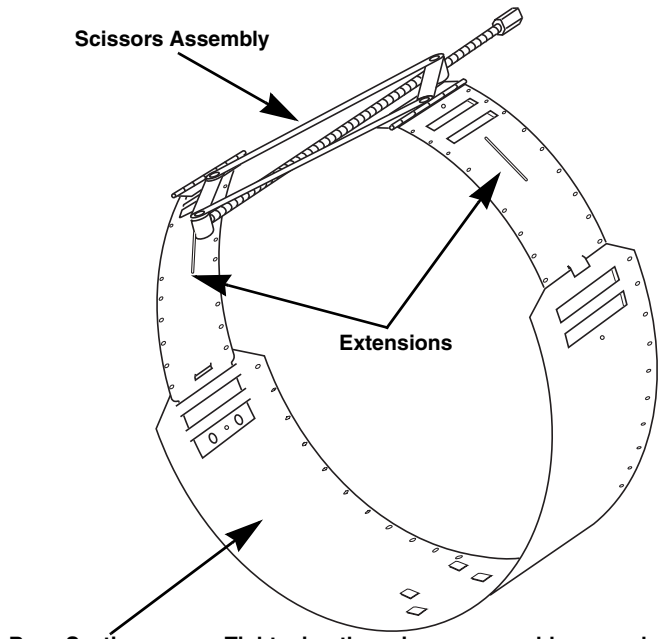


Figure 2-7 Scissors Ring Adjustment

Mounting ring kits are available for different pipe sizes. A kit is also available for partial pipe applications (consult your *Isco Mounting Rings Installation and Operation Guide*). For a listing of part numbers and ordering information, see Appendix A.

2.9.3 Completing the AV Sensor Installation

The AV sensor installation is finished by coiling any excess sensor cable and securing it using cable clamps or other means. The reference tube inside the cable can be restricted or blocked if the cable is kinked, sharply bent, or otherwise pinched. The sensor cable should be handled and mounted with care. Also, if there is any appreciable distance between the point where the sensor cable leaves the mounting apparatus and the location of the flow meter, *be sure* to attach the cable to the flow stream wall to prevent it from vibrating, moving around, tangling, or possibly collecting debris.

⚠ CAUTION

Under no circumstances should you leave any extra length of sensor cable dangling freely in the flow stream where it could trap debris or become tangled.

Use gloves and eye protection when assembling and installing the rings in a pipe. Though deburred, the edges of the stainless steel can cut if improperly handled. *Please read the information on how best to install this device.*

Observe general safety procedures when entering any manhole. See "General Safety Procedures" in the back of the manual for more information on general hazards and necessary precautions.

2.10 About Power Sources

The 4150 Flow Logger requires a 12-volt DC power source. A number of power sources are available:

- Two 6-volt alkaline lantern batteries. Lantern batteries are available from Teledyne Isco or local hardware stores.

☑ *Note*

Use only *alkaline* lantern batteries; nonalkaline batteries cannot produce sufficient power under load.

☑ *Note*

When discarding disposable alkaline batteries or any type of recyclable batteries, please dispose of them safely, observing all local environmental regulations.

- Isco 947 Lead-Acid Battery. This battery, built especially for the flow logger, is available only from Teledyne Isco.
- Isco 946 Lead-Acid Battery recharged on-site with an Isco 954 Solar Panel Battery Charger. The battery mounts on the solar panel; it does not fit in the 4150's battery compartment.
- Power from an Isco sampler. The 4150 obtains power from the sampler through the cable connecting the 4150 and the sampler.
- A 12-volt DC marine battery can also be used as a power source for the 4150. These batteries require adapter cables and must be mounted outside the 4150's case. *Do not use external power sources that produce more than 13 volts. Excessive voltage will blow the 4150's internal fuses, and may cause more serious damage.*

The 4150's battery compartment has a 3-pin connector for the Isco 947 Lead-Acid Battery. Install it as shown in Figure 2-8. The three brass contact plates on the back of the compartment fit the positive and negative contacts of alkaline batteries regardless of the batteries' orientation.

A silicon band seals the battery compartment door when the door is securely latched. Seals around the battery connectors prevent moisture from entering the electronics compartment through the connectors. A desiccant cartridge keeps the battery connectors and contact plates dry when you latch the compartment door.

2.10.1 Battery Protection and Battery Life

Lead-acid batteries can be severely damaged or destroyed if completely discharged. The 4150 protects the battery (and itself) by monitoring the voltage level of the battery. It shuts down when the voltage declines to low levels. This protects not only the battery and the 4150, but, because readings can become unreliable at low voltages, it also preserves the integrity of your data. The 4150 monitors the battery capacity and reports the remaining battery life through Flowlink.

The 4150 will not lose any data if it shuts down. Readings stored in RAM are protected by a lithium battery that provides power to the RAM when the 4150 is unpowered; for example, when the 4150 shuts down or when you replace the battery. The lithium battery also maintains the 4150's clock so that you do not have to reset it after battery changes.



Figure 2-8 Installing the 947 Lead-Acid Battery



Figure 2-9 Installing Alkaline Batteries

Place an alkaline battery at each end of the battery compartment so that the battery springs contact the brass contact plates at the bottom of the compartment. To complete the circuit, the plates extend from one end of the compartment to the other. A short section of nonconducting tape insulates the plates at the center of the compartment, preventing the batteries from touching the wrong contact plate and creating a short circuit.

If the insulating tape becomes damaged, have it replaced immediately. A short circuit in the compartment can severely damage the flow logger's case.

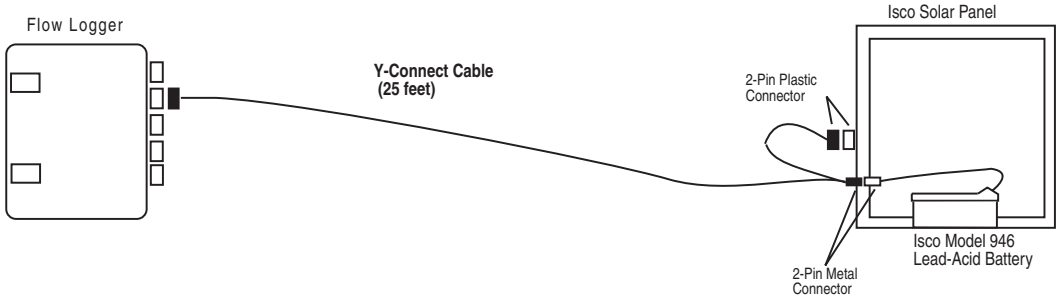


Figure 2-10 Connecting Solar Panels to the 4150

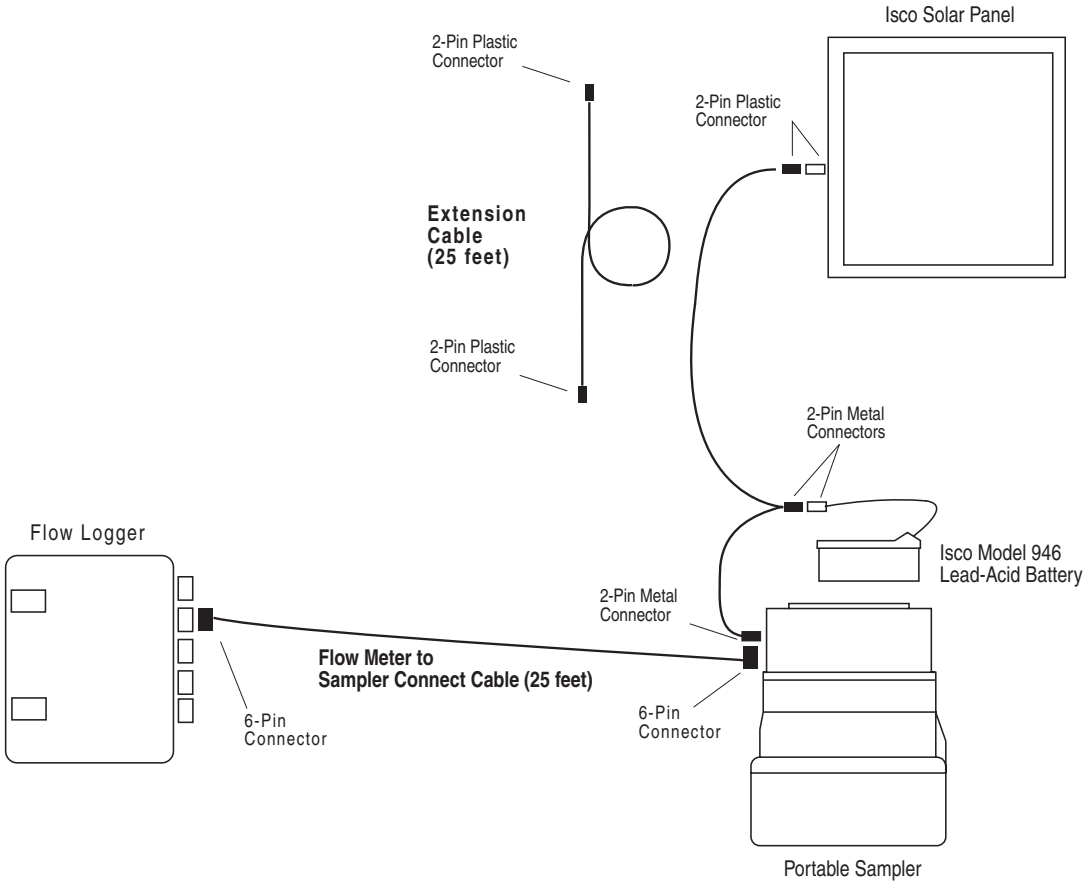


Figure 2-11 Connecting a Solar Panel and a Sampler to the 4150

2.10.2 Low Power Consumption

The 4150 Flow Logger consumes very little power. Although the actual power consumed by a flow logger depends on many variables, one is most significant: the frequency of readings.

The frequency of readings determines power consumption because the 4150 shuts down between readings. If you have programmed the flow logger to take frequent readings — at intervals of 5 minutes, for example — you can expect the flow logger to consume about six times more power than a flow logger programmed to take readings every 30 minutes.

Under most conditions, two fully charged, 6-volt alkaline batteries will power the 4150 as long as 3 months without recharging or replacement when readings are taken at 15-minute intervals. The 947 Lead-Acid Battery has about one-third that capacity. You can also power the 4150 for longer periods with a lead-acid battery that is recharged daily by a solar panel.

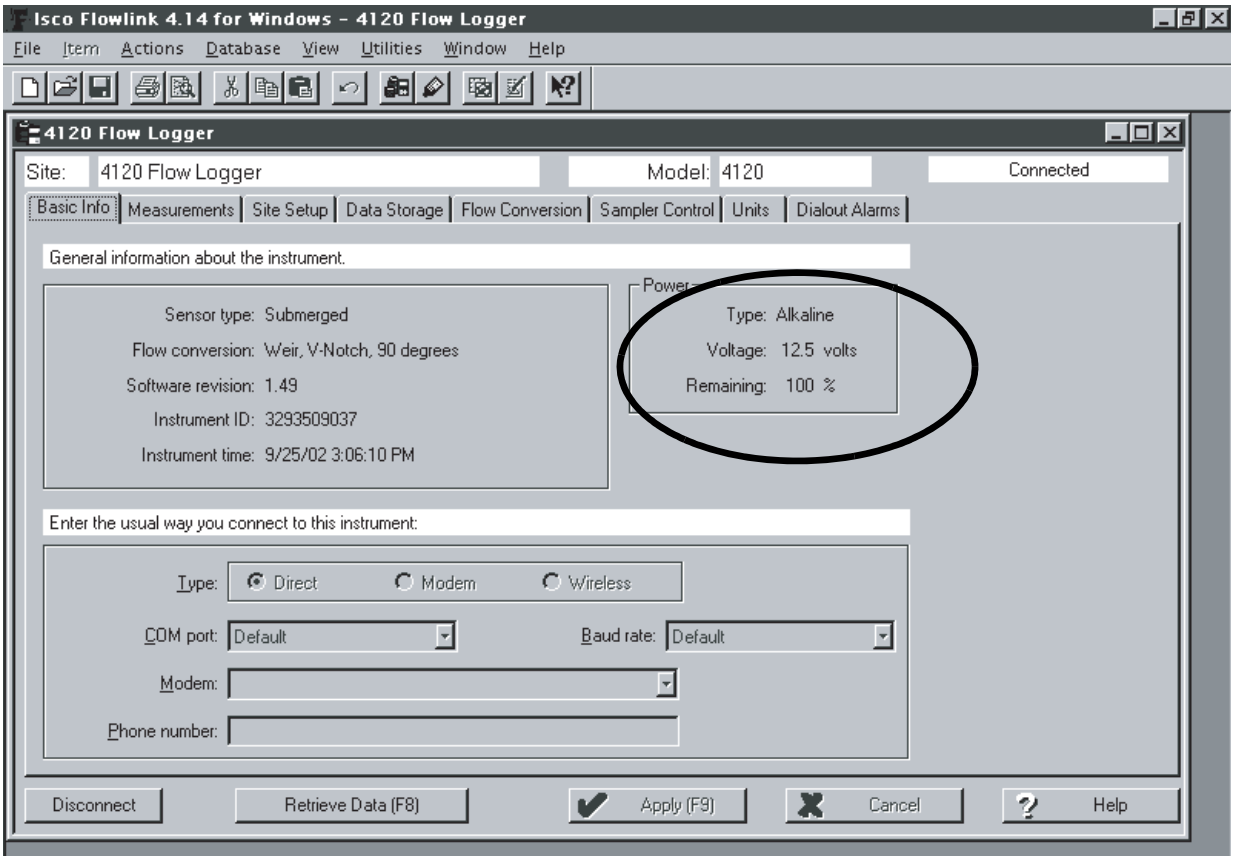


Figure 2-12 Remaining Battery Life Displayed in Flowlink

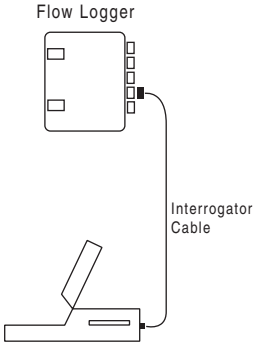
Even though you can expect a battery life of 3 months, you should check the remaining battery life regularly. The flow logger reports battery use when connected to a computer running Flowlink. (See Figure 2-12.) You can use this information to prevent lost readings by scheduling a battery replacement before the current battery becomes completely drained.

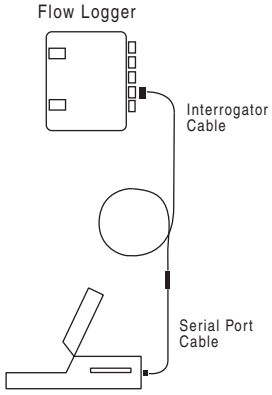
Flowlink reports the type of battery, the voltage present, and the remaining battery capacity in the Power box. When the flow logger obtains power from an external power source, Flowlink reports the battery type as “external” and will not calculate the capacity.

2.10.3 How Does the Flow Logger Conserve Power?

The 4150 conserves power by providing power to the circuitry only under certain conditions. These conditions occur when the 4150 must:

- **Respond to a signal from a tipping-bucket rain gauge.** The 4150 responds to a rain gauge signal only when programmed to store rainfall data or to monitor rainfall readings for sampler-enable controls.
- **Take a reading.** Flowlink determines the interval between readings (1, 2, 5, 10, 15, 30, 60, or 120 minutes) as part of the 4150’s program.





- **Send a pacing pulse to a sampler**. A pulse is an electronic signal. When flow pacing a sampler, a pulse represents a certain volume of water: 100 gallons; 5,000 cubic feet; or other volume setting entered with Flowlink. When trigger pacing a sampler, however, a pulse represents one of two possible time intervals. For more information in flow pacing and trigger pacing, see the *Flowlink Help*.
- To conserve power, the 4150 must do as many tasks as possible when powered. So, it sends pulses while taking readings. If the 4150 has measured a large volume of water or if the trigger pacing interval is shorter than the reading interval, it may send several flow pulses at once.
- **Respond to a computer.** The 4150 responds to a computer when it detects a completed circuit created by connecting a Computer Connect Cable to the flow logger's Interrogator connector. **Leaving the cable connected to the flow logger drains power unnecessarily.**
- Teledyne Isco also supplies a pair of cables, the Flow Meter Interrogator Cable and the Serial Port Cable, to interrogate flow meters. These cables are compatible with the flow logger. The computer-detecting circuit is in the 4-pin connectors that attach the cables to each other. **Note: Leaving the Serial Port Cable and the Interrogator Cable attached to each other while the interrogator cable is attached to the flow logger will drain the battery.**
- **Respond to a sample-event signal from a sampler**. A sample-event signal is an electronic signal called an event mark, sent by the sampler that indicates the sampler has completed a sample.
- The 4150 responds to a sample-event signal only when programmed to store sample-event data. When it receives an event signal, the 4150 records the time of the event mark and the bottle receiving the sample.

2.10.4 Adapter Cables for Alternative Power Sources

Teledyne Isco provides three power-source adapter cables. (See Figure 2-13.) The first connects an Isco 947 Lead-Acid Battery to the Isco 965 Five Station Battery Charger. Because the 947 Lead-Acid Batteries use a different connector than the other Isco batteries, the adapter is necessary to connect the 947 Lead-Acid Batteries to the charger.

The second cable connects the AC Power Pack to the 4150. It attaches to the flow logger's sampler connector.

The last cable, the External 12-Volt DC Source Connect Cable, connects the 4150 to a 12-volt, deep-cycle marine battery. The cable has a connector at one end that attaches to the 4150's sampler connector. The opposite end of the cable has two heavy-duty battery clips. Attach the clip stamped with a "**+**" to the positive terminal of the battery.

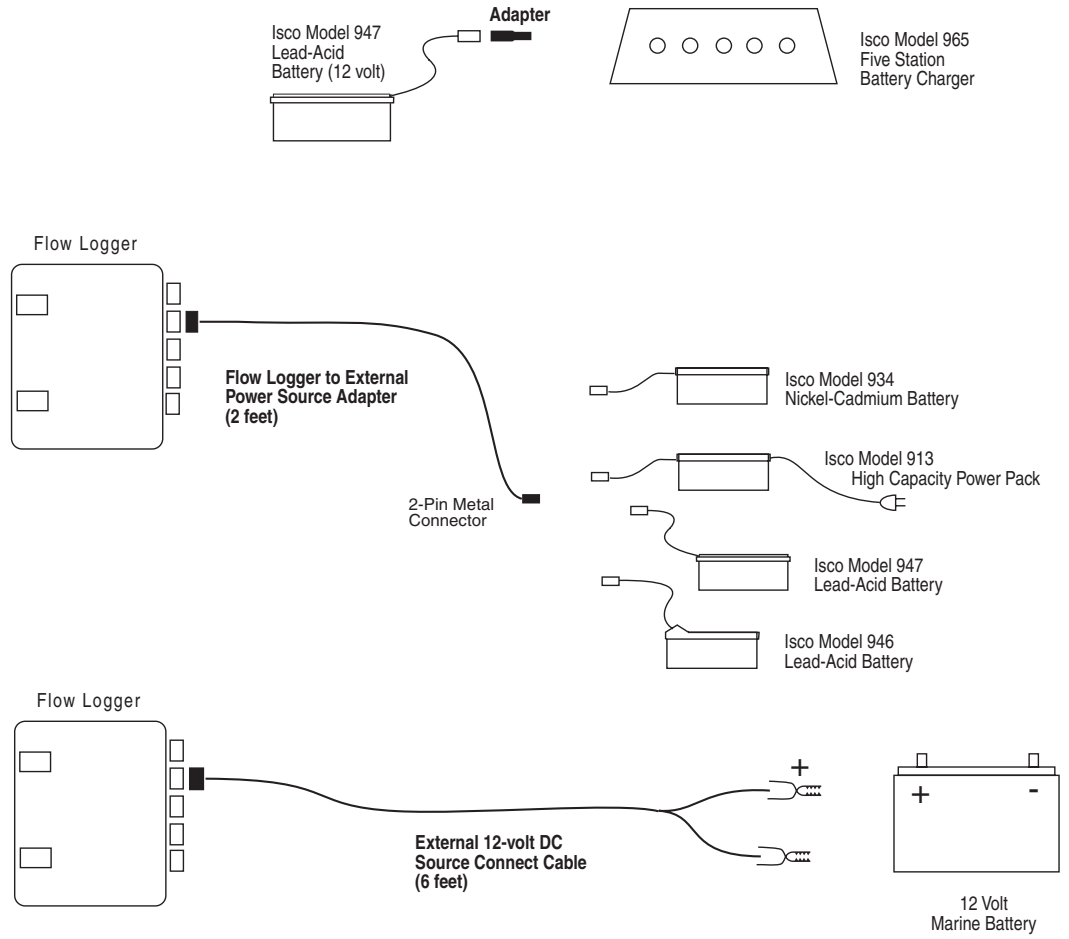


Figure 2-13 Adapters for Alternative Power Sources

2.11 Connecting the 4150 to Samplers and Rain Gauges

The 4150 Flow Logger is compatible with the Isco equipment listed below:

- 3700, GLS, Glacier, and 6700 Series Samplers
- Isco 674 Rain Gauge

A number of cables are available to connect the 4150 to samplers and the Isco 674 Rain Gauge. To connect the sampler to the 4150, attach the cable to the sampler's Flow Meter connector and the 4150's Sampler connector. To select the right cable, refer to the diagram in Figure 2-14.

2.11.1 Cables for the Rain Gauge

Attach the rain gauge cable to the 4150's Rain Gauge connector. Teledyne Isco provides a cable to connect non-Isco rain gauges to the 4150. See the Accessories List in Appendix A.

Connect the cables to the flow logger's Sampler connector and the sampler's Flow Meter connector.

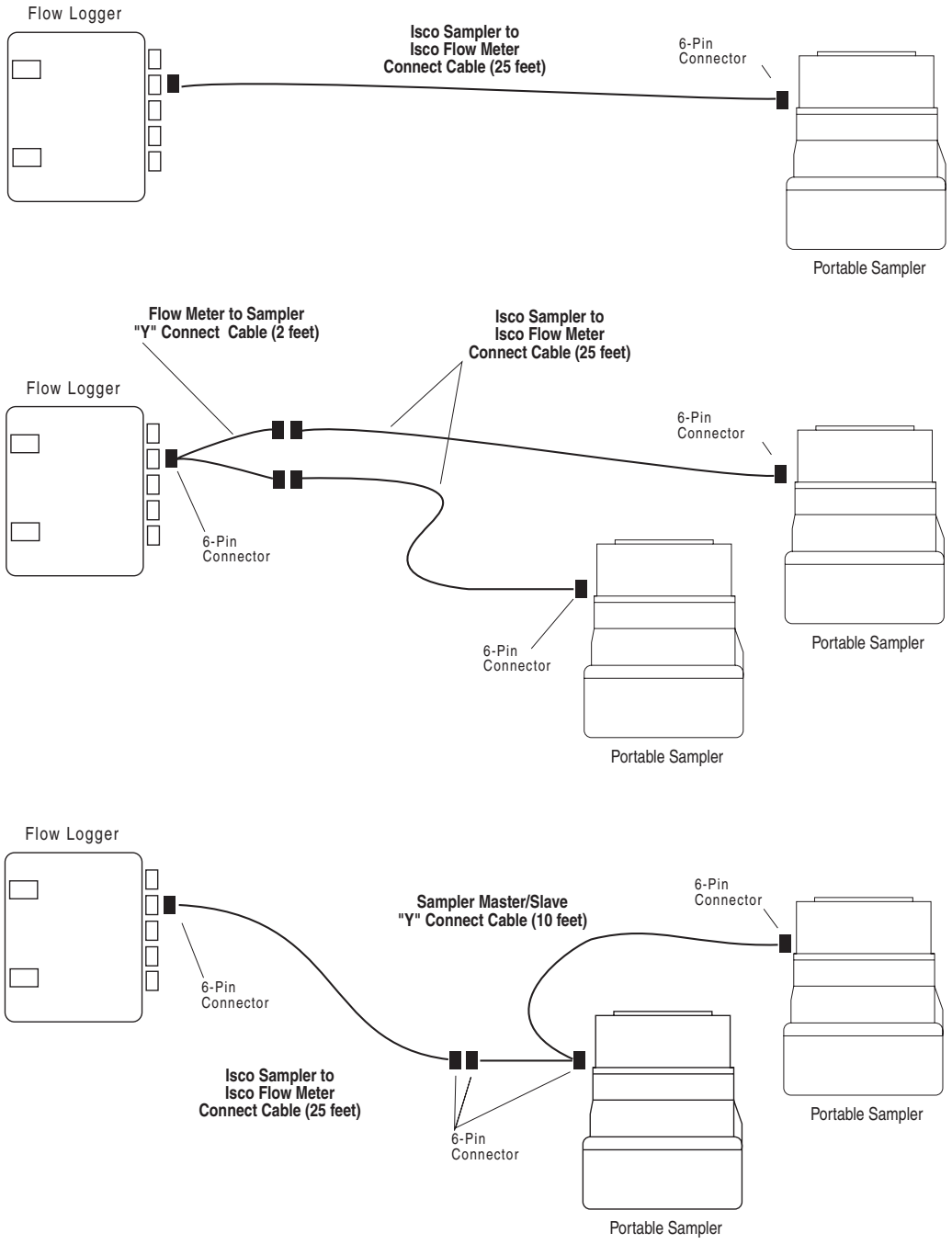


Figure 2-14 Connecting Samplers to the 4150

2.12 Quick Disconnect Box

Use the Quick Disconnect Box when you need to mount the 4150 more than 75 feet from the sensor. You can mount the Quick Disconnect Box as far as 1,000 feet (262 meters) from the 4150, but no more than 75 feet (20 meters) from the sensor's flow-stream installation. You can combine the sensor with the extension cables and Quick Disconnect Box as shown in Figure 2-15.

Use the disconnect box when you need to vent the sensor at another location than the 4150. For example, consider the following situation.

Although the primary device is in a manhole, the most convenient location for the 4150 is a nearby building. However, the building's air-handling system produces fluctuations in the air pressure. If the sensor is connected directly to the 4150 and therefore vented through the 4150, the fluctuating air pressure will distort the level and flow readings. Instead of using the 4150 to vent the sensor, mount the Quick Disconnect Box outside the building or in the manhole and vent the sensor through the box.

2.12.1 Connecting the Quick Disconnect Box to the 4150

The Quick Disconnect Box consists of a sealed Noryl® enclosure (NEMA 4x, 6) with a removable lid and a mounting bracket. The Quick Disconnect Box has a male 9-pin connector for attaching the sensor cable on one end of the box and a 1/2-inch (1.3-centimeter) NPT hole on the opposite side for custom-length cable.

Connect the Quick Disconnect Box to the 4150 with a custom-length cable that Teledyne Isco cuts to order for each customer. The cable can be as long as 1,000 feet and is supplied with a connector. This connector attaches the cable to the 4150's sensor connector.

The wires at the opposite end of the cable connect to the terminals inside the Quick Disconnect Box. If you use cable without conduit, use a cord-grip fitting to seal the box. Cord-grip fittings are available from Teledyne Isco. You can use these fittings with cable or with flexible conduit. See the Accessories List in Appendix A to select the right fitting for your cable. If you use rigid conduit, be sure to seal the box with a sealed, 1/2-inch conduit connector.

2.12.2 Mounting the Quick Disconnect Box

1. Locate the Quick Disconnect Box so that the sensor cable and its interior vent tube are not kinked or bent when connected to the box.
2. Mount the Quick Disconnect Box on a solid surface. The box has a mounting bracket with two keyholes on 3-inch (7.7-centimeter) centers.
3. Remove the top of the box.
4. Figure 2-17 shows you how to assemble the cord-grip fitting.
   Thread the cable through the fitting until there is enough lead wire to connect the cable to the barrier block noted in Figure 2-16. If you use conduit, thread the lead wires through the conduit before threading it through a compres-

sion fitting attached to the disconnect box. Be sure to seal the conduit and connector.

5. Attach the lead wires as shown in Figure 2-16.
6. Replace the top of the box.
7. Connect the sensor cable (or extension cable) to the box.

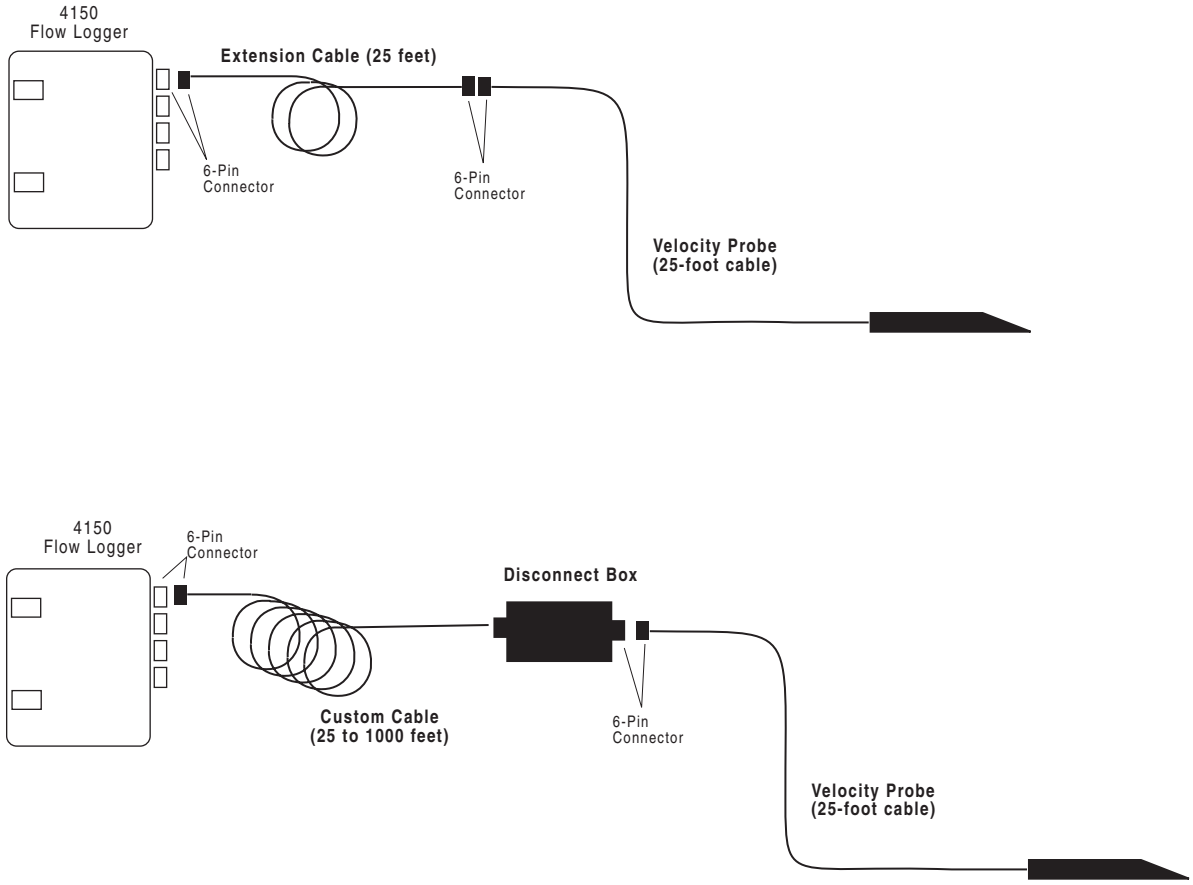


Figure 2-15 Cable Connections and the Quick Disconnect Box

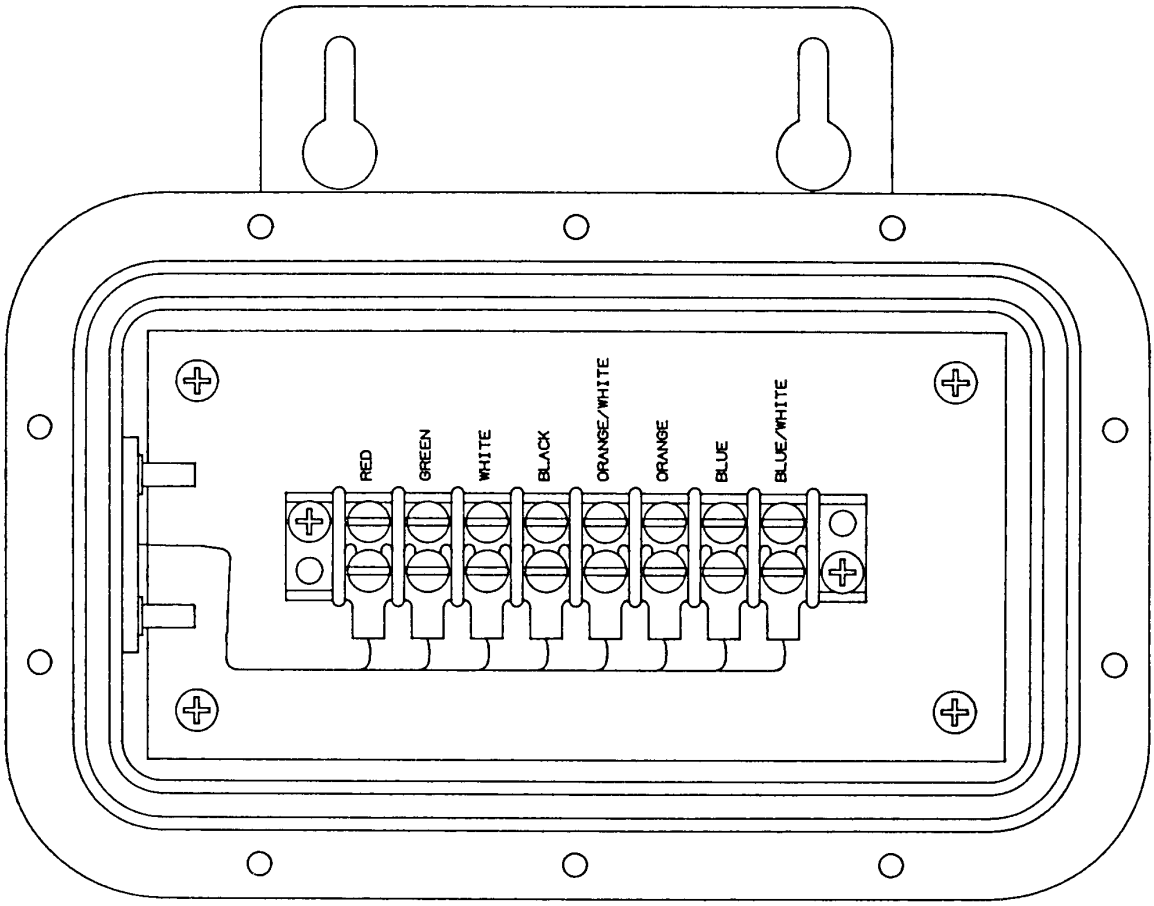


Figure 2-16 Connecting the Custom-Cable Leads to the Disconnect-Box Barrier Block

COLOR	BLOCK POSITION
Red	1
Green	2
White	3
Black	4
Orange/White	5
Orange	6
Blue	7
Blue/White	8

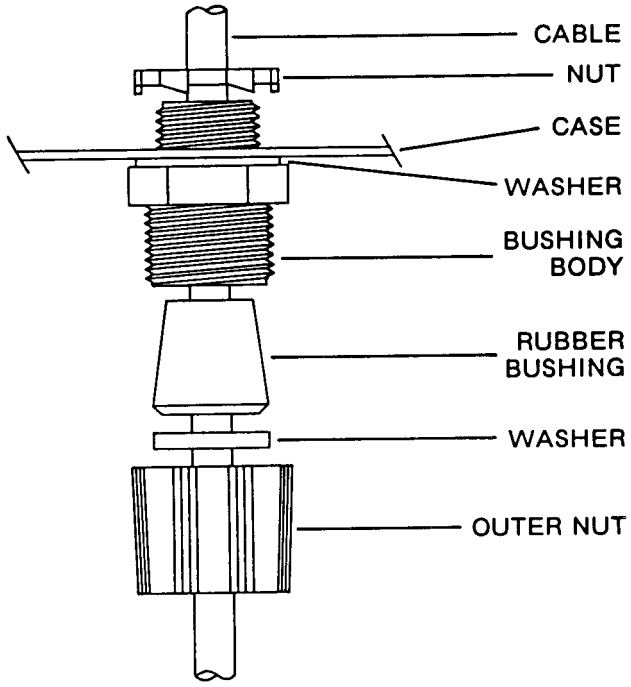


Figure 2-17 Cord-Grip Fitting

4150 Flow Logger

Section 3 Maintenance

The 4150 requires little routine maintenance. To keep the flow logger in operating condition, observe the following:

- Keep all unused connectors capped. This prevents moisture and the chemicals found in harsh environments from damaging the pins in the connectors.
- Clean the flow logger regularly.
- Clean the Area Velocity sensor, with care, when needed.
- Check the condition of the desiccant regularly, and regenerate the desiccant when necessary. (See Section 3.2.)
- Inspect the paper humidity indicator and replace it if it is white or will not return to blue within three hours after the desiccant was changed. If it indicates moisture, return the unit to Teledyne Isco. The case may be cracked or incompletely sealed.
- Replace the batteries as required. (See Section 2.10 About Power Sources. For information on recharging Isco batteries, refer to the *Isco Power Products Guide*.)

3.1 Care of the AV Sensor and Cables

The area velocity sensor and its cable require little periodic maintenance unless there is a great deal of debris in your flow stream. Certain materials that swell when wet, such as sawdust, can clog the ports of the probe, blocking the hydrostatic pressure of the stream from reaching the transducer.

The pressure transducer is on the bottom of the probe. If you remove the mounting plate from the probe body, you will see a protective plate attached with two screws. The pressure transducer is behind this disk. In general, it should not be necessary to remove this disk, and Teledyne Isco strongly recommends that you do not. In the standard AV sensors, removing the plate will expose the paper-thin diaphragm of the transducer. Read the following sections carefully before attempting to disassemble the probe.

⚠ CAUTION

If you disassemble the AV sensor for cleaning, do not touch the stainless steel diaphragm with your fingers or tools. The diaphragm is very thin (<0.003"), and easily bent.
The slightest deformation may result in damage to the transducer or the placing of a permanent offset on it. In either case the AV sensor will be ruined. Do not drop the assembly or subject it to any physical abuse.

The pressure transducer, the ultrasonic transducers, and the electronic components of the area velocity sensor are encapsulated in plastic resin and are not user-serviceable. If any part of the sensor fails, contact the Teledyne Isco Service Department.

It may be beneficial to periodically clean the flow stream up- and downstream from the area velocity sensor to maintain the hydrostatic conditions on which the level measurements and level-to-area conversions are based. The sensor was designed to expose a small frontal area and a streamlined profile to the flow, and that reduces the possibility of accumulating deposits of solid materials.

3.1.1 Cleaning the Standard AV Probe

Rarely, organic materials may become jammed inside the AV sensor's liquid ports. If this material swells as it becomes saturated with water, it may cause inaccurate pressure transmission to the level sensor. In the unlikely event that both entrance ports in the AV sensor become blocked with material that does not permit the pressure above the probe to be transmitted to the pressure transducer, you can clean the sensor with the following procedure:

1. Remove the AV sensor from the flow stream.
2. Scrape any accumulated solids from the exterior of the sensor body with a brush.
3. Remove the three screws holding the sensor carrier plate to the bottom of the probe. Be careful not to lose the small spacer disk between the the sensor mounting plate and the screw at the front of the sensor.
4. Flush the underside of the sensor with water. Do not remove the protective disk and round gasket from the level sensor unless you can see that the ports are blocked with solids.
5. If the ports are clogged and do not clear with the running water, you may have to **carefully** remove the disk and gasket. Removing the disk exposes the delicate, paper-thin metal diaphragm of the pressure transducer. **Do not touch the diaphragm with fingers or tools.**
6. Gently flush with water, without training the stream directly into the cavity. **Forcing water or air directly against the diaphragm can ruin the probe.**

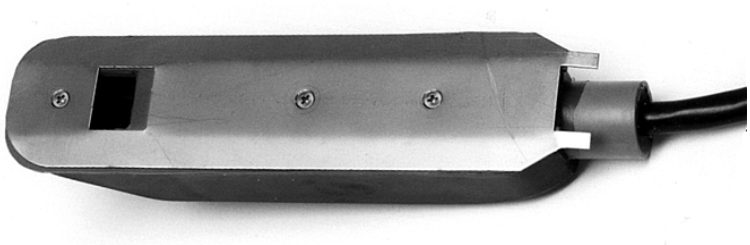


Figure 3-1 Standard AV Probe with Mounting Plate



Figure 3-2 Standard AV Probe, Protective Disk Exposed

3.1.2 Cleaning the Low Profile AV Probe

The low profile AV sensor is cleaned in the same manner as the standard AV sensor. However, the transducer is encased in stainless steel. Nevertheless, do not insert anything into the vent holes when cleaning the transducer area.



Figure 3-3 Low Profile AV Probe Without Mounting Plate



Figure 3-4 Low Profile Probe With Transducer Housing Revealed

3.1.3 Cable Inspection

Periodically inspect the AV sensor cable for wear caused by abuse or exposure to the elements. Damaged cables can affect the operation of the probe, particularly if the reference port vent tube inside the cable is collapsed or blocked. Unless the damage is very close to the connector, which can be replaced, a probe with a damaged cable is not repairable.

Keep connectors clean and dry. Although connectors are sealed, if moisture penetrated a loose connection or uncapped connector, the connector and/or probe could be ruined. In permanent installations, install the cables so they are not at risk of damage resulting from other activity taking place in the area.

In temporary installations, do not leave cables lying around where they may be run over by heavy equipment. Do not leave extra cable loose in the flow stream where it can tangle and trap debris.

In permanent installations, cables repeatedly subjected to rough environments will fail and should be installed in conduit for protection. The conduit will have to be large enough to pass the connector.

> ☑ ***Note***
>
> Avoid putting heavy pressure on the probe cable or making sharp bends in it when installing or servicing the probe. Excessive pressure may collapse the cable, crushing the reference vent tube. Sharp bends may cause the cable to kink, also blocking the vent.
> When securing the cable with plastic cable ties, tighten them only enough to secure the cable; do not tighten them so much that the cable jacket is visibly deformed.

3.2 Desiccants

Because it is frequently installed in humid environments, the 4150 Flow Logger uses desiccators to prevent moisture damage to its components:

- A desiccant bag is located in the electronics compartment.
- A desiccant cartridge is located inside the battery compartment.
- A desiccant tube on the exterior of the case. This desiccator dries the sensor's vent tube to prevent condensed moisture from blocking the tube.

3.2.1 Recharging the Desiccant Bag

A paper humidity indicator on the side of the case, labeled "INTERNAL CASE HUMIDITY," shows the relative humidity in the compartment. The desiccant bag should be replaced when the area marked "30" turns pink.

> ☑ ***Note***
>
> Teledyne Isco does not recommend recharging the internal desiccant bag yourself because you must open the case, breaking the NEMA 6 seal that prevents moisture and corrosive atmospheres from destroying the circuitry. Instead, if you think the desiccant bag requires recharging, contact Customer Service for assistance. Excessive humidity in the case may indicate that the case or case seal requires repair.

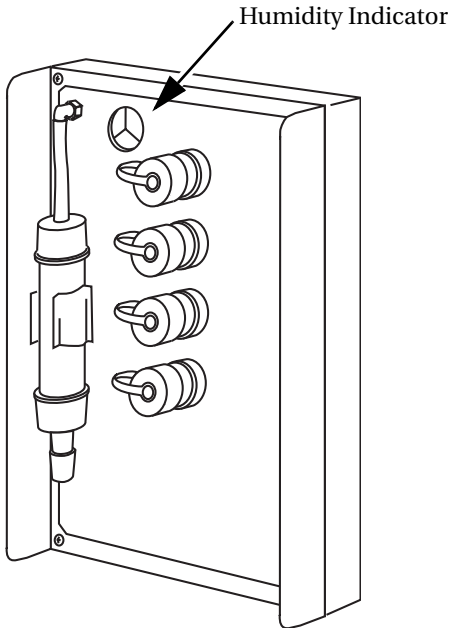


Figure 3-5 Location of the Humidity Indicator

3.2.2 When to Recharge the Desiccant Cartridge

The metal desiccant cartridge, located in the battery compartment, has an inspection window that shows the silica gel desiccant inside. The desiccant is blue or yellow when dry. Recharge the desiccant cartridge when the particles turn pink or green.

The desiccant cartridge requires periodic recharging to dry it after it becomes saturated with moisture. After repeated recharging, it eventually requires replacement. Table 3-1 shows you how to recharge the desiccant cartridge and when to replace it.

3.2.3 When to Recharge the Desiccant in the Tubes

Both the 4150 Flow Logger and the optional Quick Disconnect Box dry the probe's vent tube with a desiccant tube. Inspect the desiccant tube frequently. Exposed to humid air constantly, the desiccant will become saturated quickly. If the desiccant is unable to dry the vent tube and the tube becomes blocked with moisture, the level readings will be unreliable, and the probe can suffer permanent internal damage.

Teledyne Isco uses two types of silica gel (SiO_2) in the desiccant tubes:

- One looks like small beads or pellets that are blue-black when dry, pale pink to transparent when saturated.
- The other looks like coarse sand, yellow when dry, dark green when saturated.

Regenerate desiccant by heating at 212• - 350• (100• - 175•C).

Another type of desiccant may be used in the tubes: anhydrous calcium sulfate ($CaSO_4$). Calcium sulfate looks like rough chips of tinted plaster and changes from blue when dry to rose-red

when saturated. Regenerate the calcium sulfate desiccant before all the desiccant in the tube turns rose-red. **Do not use calcium sulfate in the metal desiccant cartridge.**

The filters in the ends of the desiccant tube prevent desiccant particles from entering the vent line. When they become soiled, wash with dish soap and water, then allow them to dry.

The desiccant in the tube requires periodic recharging to dry it after it becomes saturated with moisture. After repeated recharging, it eventually requires replacement. Table 3-1 shows you how to recharge the desiccant in the tube and when to replace it.

☑ *Note*

Both desiccants, anhydrous calcium sulfate and silica gel, are regenerated in the same way but require different temperatures. Calcium sulfate requires temperatures of 400• to 450• F; silica gel requires temperatures of 212• to 350• F.

Either chemical may produce irritating fumes when heated. See Appendix C Material Safety Data Sheets for silica gel desiccant information.

To regenerate all desiccators safely, follow these guidelines:

Always use a vented, circulating forced air convection oven in a well ventilated room.

DO NOT use a microwave oven to recharge the desiccant cartridge. Heating the metal cartridge case in a microwave oven will damage the oven.

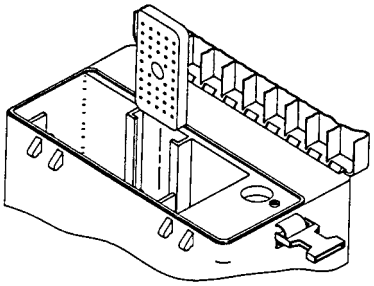
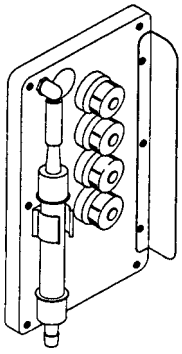
Leave the room while heating the desiccant.

Avoid heating the desiccant longer than necessary.

Use the recommended temperature. Avoid heating the desiccant at higher than recommended temperatures.

Do not heat the plastic desiccant tube. It will melt in the oven.

Table 3-1 How to Recharge the Desiccators

	Desiccant Cartridge	Desiccant Tube
Location of Desiccant	Battery Compartment 	Exterior of Case and Quick Disconnect Box 
How to Remove Desiccator	Open compartment door and slide cartridge from slot	Snap the desiccant tube from mounting clip and disconnect it
When to Recharge	Desiccant behind inspection window turns PINK or GREEN	Anhydrous Calcium Sulfate: Before all desiccant in the tube turns ROSE-RED Silica Gel: Before all desiccant in the tube turns PINK or GREEN
How to Recharge	Heat cartridge in a conventional, vented oven	Pour desiccant particles into shallow pan. Heat particles in a conventional, vented oven.
Oven Temperature	300• F (150• C)	Anhydrous Calcium Sulfate: 400•-450• F (204•-232• C) Silica Gel: 300• F (150• C)
How Long to Heat	3 hours	Anhydrous Calcium Sulfate: 1 to 2 hours Silica Gel: 3 hours
Desiccant is Recharged when:	Desiccant behind the inspection window turns BLUE or YELLOW	Desiccant particles turn BLUE or YELLOW
When to Replace	The desiccant particles no longer turn BLUE or YELLOW when recharged	The desiccant particles no longer turn BLUE or YELLOW when recharged

3.3 Fuses

If your flow logger does not seem to be operating correctly, it may have one or two bad fuses or its circuit board may need repair. You can check for problems with sensors or fuses with Flowlink's Diagnostic window. The window contains two fields, Signal Strength and Spectrum Strength, that report errors when the flow logger has at least one bad fuse or when the circuit board is malfunctioning. If the window reports “ERR” in both the Signal Strength and Spectrum Strength fields, the flow logger may have a bad fuse. (More information on the Diagnostic window appears in the *Flowlink Help*.)

> ☑ ***Note***
>
> Teledyne Isco does not recommend replacing fuses yourself because you must open the case, breaking the NEMA 6 seal that prevents moisture and corrosive atmospheres from destroying the circuitry. Instead, if you think your flow logger requires repair, contact Customer Service for information on returning it to the factory.

Customer Service Department

Teledyne Isco, Inc.
P.O. Box 82531
Lincoln, NE 6850

Telephone

Within U.S.A (toll free): (800) 228-4373
Outside U.S.A.: (402) 464-0231

FAX: (402) 465-3085

3.4 Updating the Flow Meter Software

The flow meter should be powered and turned on.

Connect your computer to the flow meter using the Computer Connect Cable (Interrogator Cable) and start the program Update Isco Instrument Software.

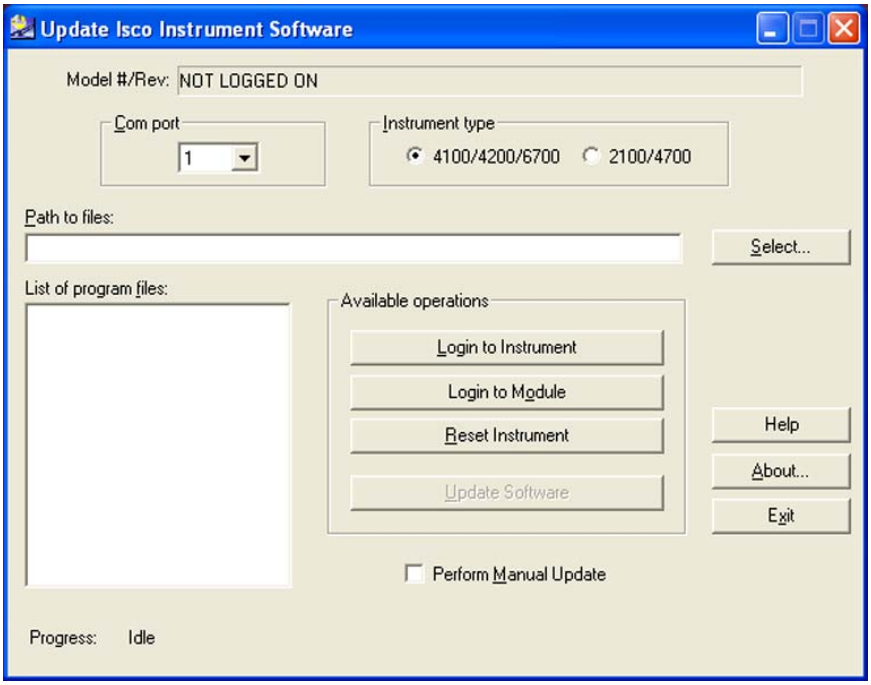


Figure 3-6 Open the software update program

Click the Help button and follow the steps listed under Update Instrument Software. Do not disturb the connection or stop the update while the file transfer is taking place. When the transfer is complete, the program displays an "Operation successful" message. Click OK and close the program.

Your flow meter's software is now updated and ready for operation.

4150 Flow Logger

Appendix A Replacement Parts and Accessories

A.1 Replacement Parts List

The following section contains a listing of replacement parts for the 4150 Area-Velocity Flow Logger, followed by a listing of optional equipment and accessories.

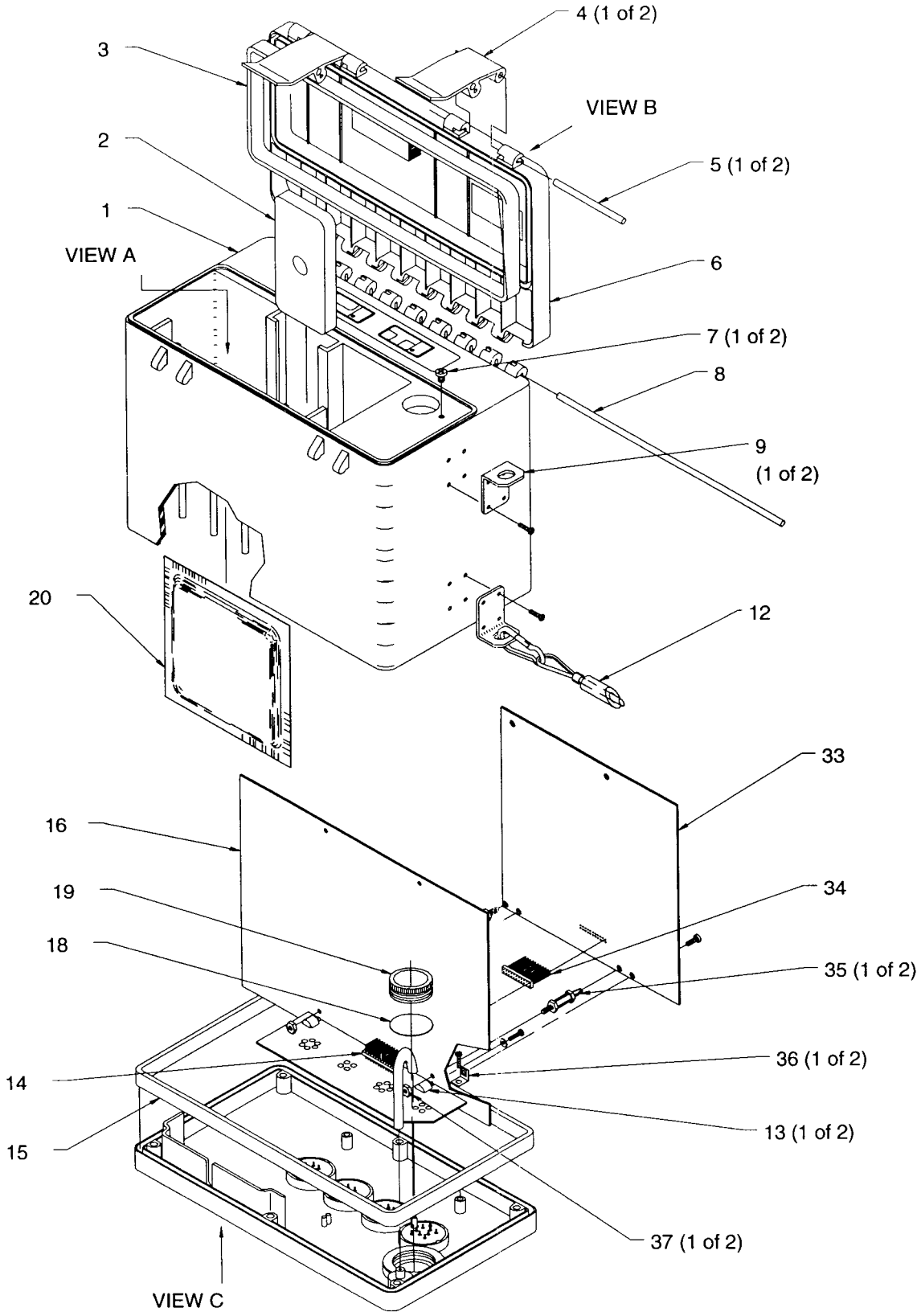
Replacement parts are called out in illustrations in this section. Reference the call-outs in the accompanying tables to determine the part number for the item.

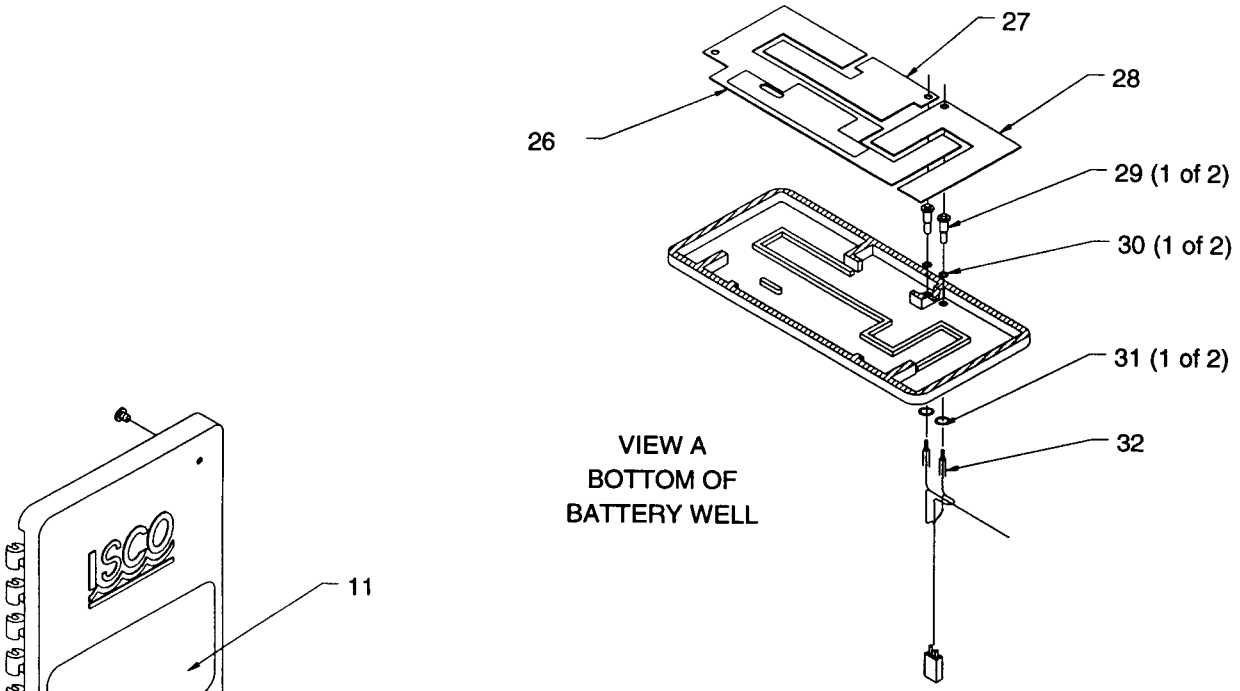
Replacement parts can be purchased by contacting Teledyne Isco's Customer Service Department.

Teledyne Isco, Inc.
Customer Service Department
P.O. Box 82531
Lincoln, NE 68501 USA

Phone: (800) 228-4373
(402) 464-0231
FAX:(402) 465-3022

E-mail:IscoInfo@teledyne.com


4 (1 of 2)
3
VIEW B
2
5 (1 of 2)
1
VIEW A
6
7 (1 of 2)
8
9
(1 of 2)
20
12
33
16
19
34
18
35 (1 of 2)
36 (1 of 2)
14
13 (1 of 2)
15
37 (1 of 2)
VIEW C


27
28
26
29 (1 of 2)
30 (1 of 2)
31 (1 of 2)
32
VIEW A
BOTTOM OF
BATTERY WELL

11
VIEW B
ROTATED 90°

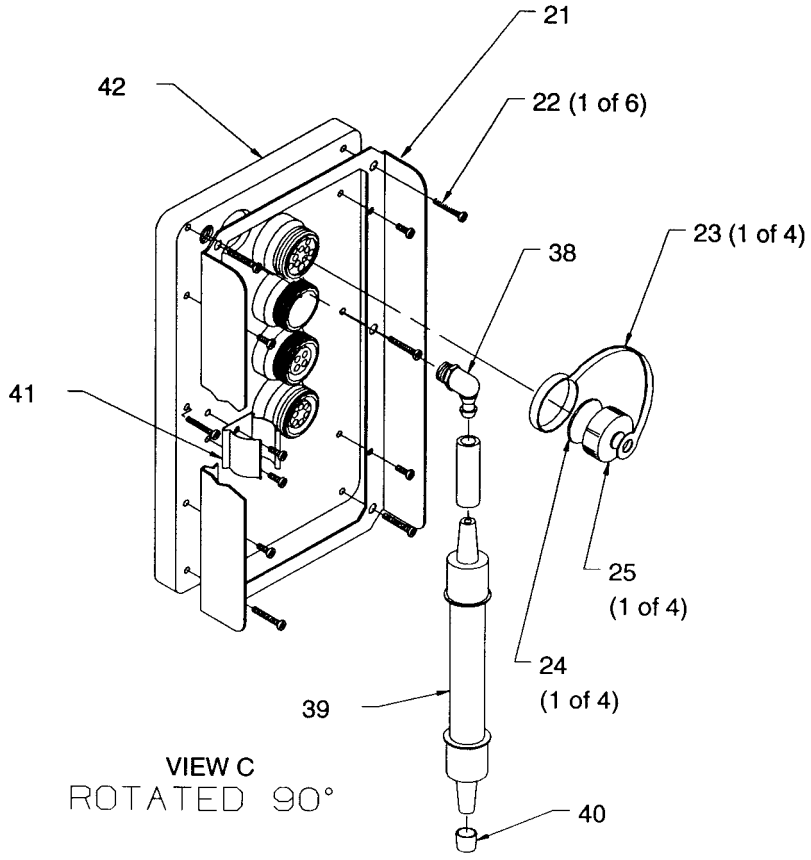

21
42
22 (1 of 6)
38
23 (1 of 4)
41
25
(1 of 4)
24
(1 of 4)
39
VIEW C
ROTATED 90°
40

Table A-1 4150 Replacement Parts List

Item	Part Number	Description
1	60-3114-009	Case Modification
2	099-0012-00	DRI-CAN Desiccant Canister
3	60-3113-029	Case Top Gasket Band
4	60-3243-124	Case Latch
5	60-3113-034	Latch
6	60-3113-070	Battery Lid Mod
7	231-0197-04	SST MS 10-32 X 1/4" PH Self Seal
8	60-3113-033	Hinge Pin
9	60-1393-049	Cable Bracket
10	60-3153-015	4150 Case Write-On Label
11	60-3153-016	4150 Case Front Label
12	60-1704-017	Carrying Handle Assembly
13	239-0416-32	Sheet Edge Fastener #6-32
14	149-3017-23	22-Pin Dual Row Header R/A.100
15	60-3113-028	Case Bottom Gasket Band
16	60-3154-017	CPU and Connector PCB Assy - Level/Velocity
17		Not Used
18	490-0013-00	Humidity Indicator Card
19	60-3113-010	Indicator Clamp
20	099-0002-08	Desiccant Bag - 4 oz.
21	60-3113-025	Case Standoff
22	231-0194-14	SST MS 6-32 X 7/8" PH Self Seal
23	60-3243-125	Connector Cap Strap
24	60-3113-032	Connector Cap Gasket
25	60-3113-024	Connector Protector Cap
26	61-3113-008	Battery Contact #1 - Plated
27	61-3113-035	Battery Contact #2 - Plated
28	61-3113-036	Battery Contact #3 - Plated
29	60-3113-009	Contact Plate Pin
30	202-1000-06	O-Ring #006 Neoprene
31	209-0001-25	Retaining Ring 5105-12 Zinc Dichr
32	60-3124-008	Wiring Harness Assembly
33	60-3154-006	Sensor PCB Assy - Level/Velocity
34	149-3017-25	22-Pin Dual Socket
35	237-9270-00	PCB Support Stud Nylon SCBS-16-01
36	232-5040-03	Right Angle Bracket Fastener
37	232-1440-00	Nylon Hex Nut 8-32
38	209-0166-65	Elbow Nylon 1/8" NPT TO 1/4" ID
39	60-1874-024	Desiccant Cartridge Assy.
40	109-0413-00	Cap .250 ID X 1/2 Long Red Vinyl
41	142-2001-00	Component Holder 3/4 X 1-1/4
42	60-3154-004	Connector Assembly - Level/Velocity

A.2 Accessories List

Power Sources and Battery Chargers

Batteries

6-Volt Alkaline Battery 340-2006-02

Disposable, 6 volts; 2 required per flow logger.

Flow Logger Lead-Acid Battery 60-3114-011

Rechargeable, 12 volts; 1 required per flow logger. Requires one of the battery chargers listed below. Also requires Flow Logger lead-acid battery charging adapter, part #68-3114-015.

Lead Acid Battery Pack 60-3004-106

Power Packs

Battery Backed Power Pack (120 VAC) 60-3004-130

Battery Backed Power Pack (240 VAC) 60-3004-160

AC power converter/battery charger with built-in battery.

High Capacity Power Pack (120 VAC) 60-1684-088

High Capacity Power Pack (240 VAC) 60-1684-093

AC power converter/battery charger.

Battery Chargers

Battery Charger 60-3004-059

120 volts AC, 50/60 Hz

Model 965 Five-Station Battery Charger, 120/240 V, with 120 V power cord. 68-3000-965

Model 965 Five-Station Battery Charger, 120/240 V, with 270 V power cord. 68-3000-966

Solar Panels

5-watt Solar Panel Battery Charger 60-5314-478

Includes solar panel, 25-foot connect cable to flow logger and battery, and instruction manual. Requires lead acid battery listed above.

40-watt Solar Panel Battery Charger 60-5314-347

110-watt Solar Panel Battery Charger 60-5314-629

Power Source Cables

Flow Logger External 12-Volt DC Source Connect Cable 60-3114-016

Connects flow logger to external 12-volt DC source. Terminates in heavy-duty battery clips.

Flow Logger External Power Connect Cable 60-3114-002

Lead-Acid Battery Charging Adapter 60-3114-015

5-watt Solar Panel Connect Cable Only 60-3114-010

Solar Panel “Y” Connect Cable Only 60-3004-098

Connect Cables

Flow Logger to External Power and Sampler “Y” Connect Cable 60-3114-001

Connects a single flow logger to two Isco-sampler-to-flow-meter connect cables and to an external power source.

Standard Y Cable for Isco Sampler 60-3704-081

Special Y Cable without diodes 60-5314-278

Connects a single flow logger to an Isco sampler-to-flow-meter connect cable

Isco Sampler to Flow Meter Connect Cable, 25-foot. 60-3004-107

Flowlink and Cables

Flowlink for Windows (software and user's manual) . . . . . call factory

For programming 4100 Series Flow Loggers, and retrieving stored flow, rainfall and sample data. Also generates a variety of graphs, reports and summaries from stored data. Operates on IBM PC or compatible computer. Includes instruction manual. Requires one of the computer connect cables listed below.

Computer Connect Cable, 9-pin. 60-2544-044

Computer Connect Cable, 25-pin. 60-2544-040

10 feet, connects computer to flow logger.

Isco Open Channel Flow Measurement Handbook 60-3003-041

Modem

4200T Modem . . . . . Factory-installed option.

Contact your sales representative or Teledyne Isco Customer Service

☑ Note

The modem is disabled when an interrogator cable is connected to the flow logger's Interrogator port. It cannot receive incoming calls, and the alarm dialout will be rendered inoperable, while this cable is connected. **Disconnect the interrogator cable in order to use the 4200T Modem.**

Area Velocity Sensors and Mounting Accessories

Area Velocity Sensor - 10-foot measurement range 60-3254-001

Area Velocity Sensor - 30-foot measurement range 60-3254-003

Low Profile AV Sensor - 10-foot measurement range. 60-3254-021

Area Velocity Extension Cable, 25-foot 60-3254-005

Spreader Bar. 60-3004-110

To suspend flow logger in manhole. Adjusts from 22.5 inches to 48.0 inches

Reference Port Tubing - 10-foot 60-2703-111

Reference Port Tubing - 25-foot 60-2703-112

Spring Rings

Probe Mounting Ring for 6" pipe 68-3200-007

Probe Mounting Ring for 8" pipe 68-3200-008

Probe Mounting Ring for 10" pipe 68-3200-009

Probe Mounting Ring for 12" pipe 68-3200-010

Probe Mounting Ring for 15" pipe 68-3200-011

Universal Mounting Ring (Scissors Ring) (for Pipes 16" diameter and larger)

Base Section (with tabs for mounting up to three probes) 60-3004-171

Scissors Assembly..... 60-3004-170
Extension 1 (9.0") 60-3004-172
Extension 2 (21.5") 60-3004-173
Extension 3 (31.5") 60-3004-174
Extension 4 (41.5") 60-3004-175

Scissors Ring Assemblies will require a base and scissors section for all sizes. Sizes from 21" to 80" will also require two or more extension sections.

Street Level Installation System

Multi-section Pole. 60-3204-012

Includes instruction manual. To complete your system, you must also order a Street Level Mounting Ring

Street Level Mounting Ring for 6" dia. pipe 60-3204-014
Street Level Mounting Ring for 8" dia. pipe 60-3204-015
Street Level Mounting Ring for 10" dia. pipe 60-3204-016
Street Level Mounting Ring for 12" dia. pipe 60-3204-017
Street Level Mounting Ring for 15" dia. pipe 60-3204-018

Miscellaneous

Sensor Mounting Plate. 68-3000-051

Includes plastic ties and instructions

L.P. AV sensor carrier. 60-3204-029

Adapter to attach the low profile sensor on mounting rings

Area Velocity Sensor Quick Disconnect Box

Area Velocity Sensor Quick Disconnect Box 60-3254-004

Provides an external connection point for connecting the 4150 to a velocity sensor through conduit. Includes desiccator for sensor vent. Maximum distance between disconnect box and 4150 is 1,000 feet. Contact the factory for information on cables between the disconnect box and the 4150. For nonconduit wiring, a watertight cord-grip fitting, listed below, is required.

Watertight Cord-Grip Fitting (for 0.19-inch to 0.20- inch diameter cable). 209-0076-05
Watertight Cord-Grip Fitting (for 0.25-inch to 0.31-inch diameter cable) 209-0076-04
Watertight Cord-Grip Fitting (for 0.31-inch to 0.37-inch diameter cable) 209-0076-03
Watertight Cord-Grip Fitting (for 0.37-inch to 0.44-inch diameter cable) 209-0076-06
Watertight Cord-Grip Fitting (for 0.44-inch to 0.50-inch diameter cable) 209-0076-07
Watertight Cord-Grip Fitting (for 0.50-inch to 0.56-inch diameter cable) 209-0076-08

Rain Gauge

Isco 674 Rain Gauge -.01-inch tip 60-3284-001
Isco 674 Rain Gauge - 0.1-millimeter tip 68-3280-001

Tipping-bucket rain gauge with 50-foot cable and connector.

Rain Gauge Connect Cable (to connect non-Isco rain gauges). 60-3004-149

Connector and 50-foot cable for connecting a non-Isco tipping-bucket rain gauge to a flow logger.

4150 Flow Logger

Appendix B General Safety Procedures

In field installations of 4150 Flow Meters and associated equipment, the safety of the personnel involved should be the foremost consideration. The following sections provide safety procedures for working in and around manholes and sewers. the first section offers general safety advice. The second section deals with the special problem of hazardous gases found in sewers.

⚠ WARNING

The 4150 Flow Logger has not been approved for use in hazardous locations as defined by the National Electrical Code.

⚠ CAUTION

Before any flow meter is installed, the proper safety precautions must be taken. The following discussions of safety procedures are only general guidelines. Each situation in which you install a flow meter varies. You must take into account the individual circumstances you are in. Additional safety considerations, other than those discussed here, may be required.

B.1 Practical Safety Precautions

The following procedures are those used by Black & Veatch, a respected consulting firm, and are published here by permission.

"Field personnel must keep safety uppermost in their minds at all times. When working above ground, rules of common sense and safety prevail. However, when entering manholes, strict safety procedures must be observed. Failure to do so could jeopardize not only your own life, but also the lives of other crew members.

"1. **Hazards.** There are many hazards connected with entering manholes. Some of the most common hazards are:

"**Adverse Atmosphere.** The manhole may contain flammable or poisonous gases or the atmosphere may be deficient in oxygen. Forced ventilation may be necessary.

"**Deteriorated Rungs.** Manhole steps may be corroded and not strong enough to support a man. It may be difficult to inspect the rungs because of poor lighting.

"**Traffic.** Whenever manholes are located in the traveled way, barricades and warning devices are essential to direct traffic away from an open manhole.

"**Falling Object.** Items placed near the manhole opening may fall and injure a worker in the manhole.

"**Sharp Edges.** Sharp edges of items in or near a manhole may cause cuts or bruises.

"**Lifting Injuries.** Unless proper tools are used to remove manhole covers, back injuries or injuries to hands or feet may result.

"2. **Planning.** Advance planning should include arrangements for test equipment, tools, ventilating equipment, protective clothing, traffic warning devices, ladders, safety harness, and adequate number of personnel. Hasty actions may result in serious injuries. Time spent in the manhole should be kept to a minimum.

"3. **Adverse Atmosphere.** [Refer to Table B-1, Hazardous Gases, at the end of this appendix.] Before workers enter a manhole, tests should be made for explosive atmosphere, presence of hydrogen sulfide, and oxygen deficiency. Combustible or toxic vapors may be heavier than air, so the tests on the atmosphere must be run at least 3/4 of the way down the manhole.

"Whenever adverse atmosphere is encountered, forced ventilation must be used to create safe conditions. After the ventilating equipment has been operated for a few minutes, the atmosphere in the manhole should be retested before anyone enters the manhole.

"When explosive conditions are encountered, the ventilating blower should be placed upwind to prevent igniting any gas that is emerging from the opening. When a gasoline engine blower is used, it must be located so that exhaust fumes cannot enter the manhole.

"If testing equipment is not available, the manhole should be assumed to contain an unsafe atmosphere and forced ventilation must be provided. It should never be assumed that a manhole is safe just because there is no odor or the manhole has been entered previously.

"4. **Entering Manholes.** Since the top of the manhole is usually flush with the surrounding surface, there may not be anything for the person who is entering the manhole to grab on to steady himself. Persons who are entering manholes should not be permitted to carry anything in their hands as they enter the manhole, to ensure that their hands will be free to hold on or grab if they slip. A good method for entering a manhole is to sit on the surface facing the manhole steps or ladder, with the feet in the hole and the arms straddling the opening for support. As the body slides forward and downward, the feet can engage a rung, and the back can rest against the opposite side of the opening. If there is any doubt about the soundness of the manhole steps, a portable ladder should be used.

"A person should never enter a manhole unless he is wearing personal safety equipment, including a safety harness and a hard hat. Two persons should be stationed at the surface continuously while anyone is working inside a manhole, to lift him out if he is

overcome or injured. One man cannot lift an unconscious man out of a manhole. The persons stationed at the surface should also function as guards to keep people and vehicles away from the manhole opening. To avoid a serious injury, a person should not be lifted out of a manhole by his arm unless it is a dire emergency.

"When more than one person must enter a manhole, the first person should reach the bottom and step off the ladder before the next one starts down. When two men climb at the same time, the upper one can cause the lower one to fall by slipping or stepping on his fingers.

"5. **Traffic Protection.** In addition to traffic cones, markers, warning signs, and barricades, a vehicle or a heavy piece of equipment should be placed between the working area and oncoming traffic. Flashing warning signals should be used to alert drivers and pedestrians. Orange safety vests should be worn by personnel stationed at the surface when the manhole is located in a vehicular traffic area.

"6. **Falling Object.** All loose items should be kept away from the manhole opening. This applies to hand tools as well as stones, gravel and other objects.

"7. **Removing the Covers.** Manhole covers should be removed with a properly designed hook. Use of a pick ax, screwdriver, or small pry bar may result in injury. A suitable tool can be made from 3/4-inch round or hex stock. Two inches of one end should be bent at a right angle and the other end should be formed into a D-handle wide enough to accommodate both hands. Even with this tool, care must be exercised to prevent the cover from being dropped on the toes. The 2-inch projection should be inserted into one of the holes in the cover, the handle grasped with both hands, and the cover lifted by straightening the legs which have been slightly bent at the knees.

"8. **Other Precautions.** Other precautions which should be taken when entering a manhole are:

- Wear a hard hat.
- Wear coveralls or removable outer garment that can be readily removed when the work is completed.
- Wear boots or nonsparking safety shoes.
- Wear rubberized or waterproof gloves.
- Wear a safety harness with a stout rope attached.
- Do not smoke.
- Avoid touching yourself above the collar until you have cleaned your hands.

"9. **Emergencies.** Every member of the crew should be instructed on procedures to be followed in cases of an emergency. It is the duty of each crew chief to have a list of emergency phone numbers, including the nearest hospital and ambulance service, police precinct, fire station, and rescue or general emergency number.

"10. **Field Equipment.** The following equipment will be available for use:

Blowers	Gloves	Traffic cones
Breathing apparatus	Hard Hats	Coveralls
Harnesses	First aid kits	Manhole irons
Emergency flashers	Pick axes	Flashlights
Rain slickers	Mirrors	Ropes
Gas detectors	Safety vests	Gas masks
Waders"		

B.2 Lethal Atmospheres in Sewers

The following is an article written by Dr. Richard D. Pomeroy, and published in the October 1980 issue of *Deeds & Data* of the WPCF. Dr. Pomeroy is particularly well known for his studies, over a period of nearly 50 years, in the field of the control of hydrogen sulfide and other odors in sewers and treatment plants. He has personally worked in a great many functioning sewers. In the earlier years he did so, he admits, with little knowledge of the grave hazards to which he exposed himself.

"It is gratifying that the subject of hazards to people working in sewers is receiving much more attention than in past years, and good safety procedures are prescribed in various publications on this subject. It is essential that people know and use correct procedures.

"It is less important to know just what the hazardous components of sewer atmospheres are, as safety precautions should in general be broadly applicable, but there should be a reasonable understanding of this subject. It is disturbing to see statements in print that do not reflect true conditions.

"One of the most common errors is the assumption that people have died from a lack of oxygen. The human body is able to function very well with substantially reduced oxygen concentrations. No one worries about going to Santa Fe, New Mexico, (elev. 2,100 meters), where the partial pressure of oxygen is equal to 16.2% (a normal atmosphere is about 21%) oxygen. When first going there, a person may experience a little 'shortness of breath' following exercise. People in good health are not afraid to drive over the high passes in the Rocky Mountains. At Loveland Pass, oxygen pressure is 13.2% of a normal atmosphere. At the top of Mt. Whitney, oxygen is equal to 12.2%t. Many hikers go there, and to higher peaks as well. After adequate acclimation, they may climb to the top of Mt. Everest, where oxygen is equal to only 6.7%.

"The lowest oxygen concentrations that I have observed in a sewer atmosphere was 13 percent. It was in a sealed chamber, near sea level, upstream from an inverted siphon on a metropolitan trunk. A man would be foolish to enter the chamber. Without ventilation, he might die, but not from lack of oxygen.

"It seems unlikely that anyone has ever died in a sewer from suffocation, that is, a lack of oxygen. Deaths have often been attributed to 'asphyxiation.' This is a word which, according to the dictionary, is used to mean death from an atmosphere that does not support life. The word has sometimes been misinterpreted as meaning suffocation, which is only one kind of asphyxiation.

"In nearly all cases of death in sewers, the real killer is hydrogen sulfide. It is important that this fact be recognized. Many cities diligently test for explosive gases, which is very important, and they may measure the oxygen concentration which usually is unimportant, but they rarely measure H_2S. Death has occurred where it is unlikely that there was any measurable reduction in the oxygen concentration. Waste water containing 2 mg per liter of dissolved sulfide, and at a pH of 7.0, can produce, in a chamber with high turbulence, a concentration of 300 PPM H_2S, in the air. This is considered to be a lethal concentration. Many people have died from H_2S, not only in sewers and industries, but also from swamps and from hot springs. In one resort area, at least five persons died from H_2S poisoning before the people were ready to admit that H_2S is not a therapeutic agent. Hardly a year passes in the U.S. without a sewer fatality from H_2S as well as deaths elsewhere in the world.

"The presence of H_2S in a sewer atmosphere is easily determined. A bellows-and-ampoule type of tester is very satisfactory for the purpose, even though it is only crudely quantitative. When using a tester of this type, do not bring the air to the ampoule by way of a tube, as this may change the H_2S concentration. Hang the ampoule in the air to be tested, with a suction tube to the bulb or bellows.

"Lead acetate paper is very useful as a qualitative indicator. It cannot be used to estimate the amount of sulfide, but it will quickly turn black in an atmosphere containing only a tenth of a lethal concentration.

"Electrodes or other similar electrical indicating devices for H_2S in air have been marketed. Some of them are known to be unreliable, and we know of none that have proved dependable. Do not use one unless you check it at frequent intervals against air containing known H_2S concentrations. A supposed safety device that is unreliable is worse than none at all.

"Remember that the nose fails, too, when it comes to sensing dangerous concentrations of H_2S.

"Various other toxic gases have been mentioned in some publications. It is unlikely that any person has been asphyxiated in a sewer by any of those other gases, except possibly chlorine. The vapor of gasoline and other hydrocarbons is sometimes present in amounts that could cause discomfort and illness, but under that condition, the explosion hazard would be far more serious. The explosimeter tests, as well as the sense of smell, would warn of the danger. Pipelines in chemical plants might contain any

number of harmful vapors. They, too, are sensed by smell and explosimeter tests if they get into the public sewer. Such occurrences are rare.

"The attempt to instill a sense of urgency about real hazards is diluted if a man is told to give attention to a long list of things that in fact are irrelevant.

"Be very careful to avoid high H_2S concentrations, flammable atmospheres, and hazards of physical injuries. Remember that much H_2S may be released by the stirring up of sludge in the bottom of a structure. Obey your senses in respect to irritating gases, such as chlorine (unconsciousness comes suddenly from breathing too much). Be cautious about strange odors. Do not determine percent oxygen in the air. There is a danger that the result will influence a man's thinking about the seriousness of the real hazards. Most important, use ample ventilation, and do not enter a potentially hazardous structure except in a good safety harness with two men at the top who can lift you out."

B.3 Hazardous Gases

The following table contains information on the properties of hazardous gases.

Table B-1 Hazardous Gases

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Ammonia	NH_3	Irritant and poisonous. Colorless with characteristic odor.	0.60	Causes throat and eye irritation at 0.05%, coughing at 0.17%. Short exposure at 0.5% to 1% fatal.	300 to 500	85	16 25	Near top. Concentrates in closed upper spaces	Sewers, chemical feed rooms.	Detectable odor at low concentrations
Benzene	C_6H_6	Irritant, colorless anesthetic	2.77	Slight symptoms after several hours exposure at 0.16% to 0.32%. 2% rapidly fatal.	3,000 to 5,000	25	1.3 7.1	At bottom.	Industrial wastes, varnish, solvents.	Combustible gas indicator
Carbon Bisulfide	CS_2	Nearly odorless when pure, colorless, anesthetic. Poisonous.	2.64	Very poisonous, irritating, vomiting, convulsions, psychic disturbance.	—	15	1.3 44.0	At bottom	An insecticide	Combustible gas indicator
Carbon Dioxide	CO_2	Asphyxiant, Colorless, odorless. When breathed in large quantities, may cause acid taste. Non-flammable. Not generally present in dangerous amounts unless an oxygen deficiency exists.	1.53	Cannot be endured at 10% more than a few minutes, even if subject is at rest and oxygen content is normal. Acts on respiratory nerves.	40,000 to 60,000	5,000	— —	At bottom; when heated may stratify at points above bottom.	Products of combustion, sewer gas, sludge. Also issues from carbonaceous strata.	Oxygen deficiency indicator

Table B-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Carbon Monoxide	CO	Chemical asphyxiant. Colorless, odorless, tasteless. Flammable. Poisonous.	0.97	Combines with hemoglobin of blood. Unconsciousness in 30 min. at 0.2% to 0.25%. Fatal in 4 hours at 0.1%. Headache in few hours at 0.02%.	400	50	12.5 74.0	Near top, especially if present with illuminating gas.	Manufactured gas, flue gas, products of combustion, motor exhausts. Fires of almost any kind.	CO ampoules.
Carbon Tetra-Chloride	CCl_4	Heavy, ethereal odor.	5.3	Intestinal upset, loss of consciousness, possible renal damage, respiratory failure.	1,000 to 1,500	100	— —	At bottom.	Industrial wastes, solvent, cleaning	Detectable odor at low concentrations.
Chlorine	Cl_2	Irritant. Yellow-green color. Choking odor detectable in very low concentrations. Non-flammable.	2.49	Irritates respiratory tract. Kills most animals in a very short time at 0.1%.	4	1	— —	At bottom.	Chlorine cylinder and feed line leaks.	Detectable odor at low concentrations.
Formaldehyde	CH_2O	Colorless, pungent suffocating odor.	1.07	Irritating to the nose.	—	10	7.0 73.0	Near bottom.	Incomplete combustion of organics. Common air pollutant, fungicide.	Detectable odor.
Gasoline	C_5H_{12} to C_9H_{20}	Volatile solvent. Colorless. Odor noticeable at 0.03%. Flammable.	3.0 to 4.0	Anesthetic effects when inhaled. Rapidly fatal at 2.4%. Dangerous for short exposure at 1.1 to 2.2%.	4,000 to 7,000	1,000	1.3 6.0	At bottom.	Service stations, garages, storage tanks, houses.	1. Combustible gas indicator. 2. Oxygen deficiency indicator.**
Hydrogen	H_2	Simple asphyxiant. Colorless, odorless, tasteless. Flammable	0.07	Acts mechanically to deprive tissues of oxygen. Does not support life.	—	—	4.0 74.0	At top.	Manufactured gas, sludge digestion tank gas, electrolysis of water. Rarely from rock strata.	Combustible gas indicator.
Hydrogen Cyanide	HCN	Faint odor of bitter almonds. Colorless gas	0.93	Slight symptoms appear upon exposure to 0.002% to 0.004%. 0.3% rapidly fatal.	—	10	6.0 40.0	Near top.	Insecticide and rodenticide.	Detector tube
Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air = 1	Physiological Effect*	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air.) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing

Table B-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Hydrogen Sulfide	H_2S	Irritant and poisonous volatile compound. Rotten egg odor in small concentrations. Exposure for 2 to 15 min. at 0.01% impairs sense of smell. Odor not evident at high concentrations. Colorless. Flammable.	1.19	Impairs sense of smell, rapidly as concentration increases. Death in few minutes at 0.2%. Exposure to 0.07 to 0.1% rapidly causes acute poisoning. Paralyzes respiratory center.	200 to 300	20	4.3 45.0	Near bottom, but may be above bottom if air is heated and highly humid.	Coal gas, petroleum, sewer gas. Fumes from blasting under some conditions. Sludge gas.	1. H_2S Ampoule. 2. 5% by weight lead acetate solution.
Methane	CH_4	Simple asphyxiant. Colorless, odorless, tasteless, flammable.	0.55	Acts mechanically to deprive tissues of oxygen. Does not support life.	Probably no limit, provided oxygen percent-age is sufficient for life.	—	5.0 15.0	At top, increasing to certain depth.	Natural gas, sludge gas, manufactured gas, sewer gas. Strata of sedimentary origin. In swamps or marshes.	1. Combustible gas indicator 2. Oxygen deficiency indicator.
Nitrogen	N_2	Simple asphyxiant. Colorless, tasteless. Non-flammable. Principal constituent of air. (about 79%).	0.97	Physiologically inert.	—	—	— —	Near top, but may be found near bottom.	Sewer gas. sludge gas. Also issues from some rock strata.	Oxygen deficiency indicator.
Nitrogen Oxides	NO N_2O NO_2	Colorless Colorless, sweet odor. Reddish-brown. Irritating odor. Deadly poison	1.04 1.53 1.58	60 to 150 ppm cause irritation and coughing. Asphyxiant. 100 ppm dangerous. 200 ppm fatal.	50	10	— —	Near bottom.	Industrial wastes. Common air pollutant.	NO_2 detector tube.
Oxygen	O_2	Colorless, odorless, tasteless. Supports combustion.	1.11	Normal air contains 20.8% of O_2. Man can tolerate down to 12%. Minimum safe 8 hour exposure, 14 to 16%. Below 10%, dangerous to life. Below 5 to 7% probably fatal.	—	—	— —	Variable at different levels.	Oxygen depletion from poor ventilation and absorption, or chemical consumption of oxygen.	Oxygen deficiency indicator.
Ozone	O_3	Irritant and poisonous. Strong electrical odor. Strong oxidizer. Colorless. At 1 ppm, strong sulfur-like odor.	1.66	Max. naturally occurring level is 0.04 ppm. 0.05 ppm causes irritation of eyes and nose. 1 to 10 ppm causes headache, nausea; can cause coma. Symptoms similar to radiation damage.	0.08	0.04	— —	Near bottom.	Where ozone is used for disinfection.	Detectable odor at 0.015 ppm.
Sludge Gas	—***	Mostly a simple asphyxiant. May be practically odorless, tasteless.	Variable	Will not support life.	No data. Would vary widely with composition.		5.3 19.3	Near top of structure.	From digestion of sludge.	See components.

Table B-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Sulfur Dioxide	SO_2	Colorless, pungent odor. Suffocating, corrosive, poisonous, non-flammable.	2.26	Inflammation of the eyes. 400 to 500 ppm immediately fatal.	50 to 100	10	— —	At bottom, can combine with water to form sulfurous acid.	Industrial waste, combustion, common air pollutant.	Detectable taste and odor at low concentration.
Toluene	C_5H_{12} to C_9H_{20}	Colorless, benzene-like odor.	3.14	At 200-500 ppm, headache, nausea, bad taste, lassitude.	200	100	1.27 7.0	At bottom.	Solvent.	Combustible gas indicator.
Turpentine	$C_{10}H_{16}$	Colorless, Characteristic odor.	4.84	Eye irritation. Headache, dizziness, nausea, irritation of the kidneys.	—	100		At bottom.	Solvent, used in paint.	1. Detectable odor at low concentrations. 2.Combustible gas indicator.
Xylene	C_8H_{10}	Colorless, flammable	3.66	Narcotic in high concentrations. less toxic than benzene.	—	100	1.1 7.0	At bottom.	Solvent	Combustible gas indicator.

* Percentages shown represent volume of gas in air.
** For concentration over 0.3%.
***Mostly methane and carbon dioxide with small amounts of hydrogen, nitrogen, hydrogen sulfide, and oxygen; occasionally traces of carbon monoxide.

4150 Flow Logger

Appendix C Material Safety Data Sheets

The following section contains Material Safety Data Sheets (MSDS) regarding the desiccant used in the 4150 Flow Logger. For more information about these chemicals, contact the manufacturer.

101 Christine Drive
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 861-2355

SÜD-CHEMIE
Performance Packaging

ISO 9002

MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

SECTION I -- PRODUCT IDENTIFICATION

Trade Name and Synonyms:	Silica Gel, Synthetic Amorphous Silica, Silicon, Dioxide
Chemical Family:	Synthetic Amorphous Silica
Formula:	SiO_2.x H_2O

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

COMPONENT	CAS No	%	ACGIH/TLV (PPM)	OSHA-(PEL)
Amorphous Silica	63231-67-4	>99	PEL - 20 (RESPIRABLE), TLV – 5	LIMIT – NONE, HAZARD - IRRITANT ˝

Synthetic amorphous silica is not to be confused with crystalline silica such as quartz, cristobalite or tridymite or with diatomaceous earth or other naturally occurring forms of amorphous silica that frequently contain crystalline forms.

This product is in granular form and packed in bags for use as a desiccant. Therefore, no exposure to the product is anticipated under normal use of this product. Avoid inhaling desiccant dust.

SECTION III -- PHYSICAL DATA

Appearance and Odor:	White granules; odorless.
Melting Point:	>1600 Deg C; >2900 Deg F
Solubility in Water:	Insoluble.
Bulk Density:	>40 lbs./cu. ft.
Percent Volatile by Weight @ 1750 Deg F:	<10%.

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SORB-IT®
Packaged Desiccant

SECTION IV -- FIRE EXPLOSION DATA

Fire and Explosion Hazard - Negligible fire and explosion hazard when exposed to heat or flame by reaction with incompatible substances.

Flash Point - Nonflammable.

Firefighting Media - Dry chemical, water spray, or foam. For larger fires, use water spray fog or foam.

Firefighting - Nonflammable solids, liquids, or gases: Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in enclosed area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of the tank due to fire.

SECTION V -- HEALTH HAZARD DATA

Health hazards may arise from inhalation, ingestion, and/or contact with the skin and/or eyes. Ingestion may result in damage to throat and esophagus and/or gastrointestinal disorders. Inhalation may cause burning to the upper respiratory tract and/or temporary or permanent lung damage. Prolonged or repeated contact with the skin, in absence of proper hygiene, may cause dryness, irritation, and/or dermatitis. Contact with eye tissue may result in irritation, burns, or conjunctivitis.

First Aid (Inhalation) - Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep affected person warm and at rest. Get medical attention immediately.

First Aid (Ingestion) - If large amounts have been ingested, give emetics to cause vomiting. Stomach siphon may be applied as well. Milk and fatty acids should be avoided. Get medical attention immediately.

First Aid (Eyes) - Wash eyes immediately and carefully for 30 minutes with running water.

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MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

NOTE TO PHYSICIAN: This product is a desiccant and generates heat as it adsorbs water. The used product can contain material of hazardous nature. Identify that material and treat accordingly.

SECTION VI -- REACTIVITY DATA

Reactivity - Silica gel is stable under normal temperatures and pressures in sealed containers. Moisture can cause a rise in temperature which may result in a burn.

SECTION VII --SPILL OR LEAK PROCEDURES

Notify safety personnel of spills or leaks. Clean-up personnel need protection against inhalation of dusts or fumes. Eye protection is required. Vacuuming and/or wet methods of cleanup are preferred. Place in appropriate containers for disposal, keeping airborne particulates at a minimum.

SECTION VIII -- SPECIAL PROTECTION INFORMATION

Respiratory Protection - Provide a NIOSH/MSHA jointly approved respirator in the absence of proper environmental control. Contact your safety equipment supplier for proper mask type.

Ventilation - Provide general and/or local exhaust ventilation to keep exposures below the TLV. Ventilation used must be designed to prevent spots of dust accumulation or recycling of dusts.

Protective Clothing - Wear protective clothing, including long sleeves and gloves, to prevent repeated or prolonged skin contact.

Eye Protection - Chemical splash goggles designed in compliance with OSHA regulations are recommended. Consult your safety equipment supplier.

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ISO 9002

MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

SECTION IX -- SPECIAL PRECAUTIONS

Avoid breathing dust and prolonged contact with skin. Silica gel dust causes eye irritation and breathing dust may be harmful.

* No Information Available

HMIS (Hazardous Materials Identification System) for this product is as follows:

Health Hazard	0
Flammability	0
Reactivity	0
Personal Protection	HMIS assigns choice of personal protective equipment to the customer, as the raw material supplier is unfamiliar with the condition of use.

The information contained herein is based upon data considered true and accurate. However, United Desiccants makes no warranties expressed or implied, as to the accuracy or adequacy of the information contained herein or the results to be obtained from the use thereof. This information is offered solely for the user's consideration, investigation and verification. Since the use and conditions of use of this information and the material described herein are not within the control of United Desiccants, United Desiccants assumes no responsibility for injury to the user or third persons. The material described herein is sold only pursuant to United Desiccants' Terms and Conditions of Sale, including those limiting warranties and remedies contained therein. It is the responsibility of the user to determine whether any use of the data and information is in accordance with applicable federal, state or local laws and regulations.

Material Safety Data Sheet

Indicating Silica Gel

Identity (Trade Name as Used on Label)

Manufacturer :	MULTISORB TECHNOLOGIES, INC. (formerly Multiform Desiccants, Inc.)	MSDS Number* :	M75
Address:	325 Harlem Road Buffalo, NY 14224	CAS Number* :	
Phone Number (For Information):	716/824-8900	Date Prepared:	July 6, 2000
Emergency Phone Number:	716/824-8900	Prepared By* :	G.E. McKedy

Section 1 - Material Identification and Information

Components - Chemical Name & Common Names (Hazardous Components 1% or greater; Carcinogens 0.1% or greater)	%*	OSHA PEL	ACGIH TLV	OTHER LIMITS RECOMMENDED
Silica Gel SiO_2	98.0	6mg/m^3 (total dust)	10mg/m^3 (total dust)	
Cobalt Chloride	>2.0	0.05mg/m^3 (TWA cobalt metal dust & fume)	.05mg/m^3 (Cobalt, TWA)	
Non-Hazardous Ingredients				
TOTAL	100			

Section 2 - Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_20 = 1)	2.1
Vapor Pressure (mm Hg and Temperature	N/A	Melting Point	N/A
Vapor Density (Air =1)	N/A	Evaporation Rate (_____=1)	N/A
Solubility in Water	Insoluble, but will adsorb moisture.	Water Reactive	Not reactive, but will adsorb moisture.
Appearance and Odor	Purple crystals, no odor.		

Section 3 - Fire and Explosion Hazard Data

Flash Point and Methods Used	N/A	Auto-Ignition Temperature	N/A	Flammability Limits in Air % by Volume	N/A	LEL	UEL
Extinguisher Media	Dry chemical, carbon dioxide and foam can be used.						
Special Fire Fighting Procedures	Water will generate heat due to the silica gel which will adsorb water and liberate heat.						
Unusual Fire and Explosion Hazards	When exposed to water, the silica gel can get hot enough to reach the boiling point of water. Flooding with water will reduce the temperature to safe limits.						

Section 4 - Reactivity Hazard Data

STABILITY ☐**Stable** ☐**Unstable**	Conditions To Avoid	Moisture and high humidity environments.
Incompatibility (Materials to Avoid)	Water.	
Hazardous Decomposition Products	Carbon dioxide, carbon monoxide, water	
HAZARDOUS POLYMERIZATION ☐May Occur	Conditions To Avoid	None.

*Optional

Section 5 - Health Hazard Data

PRIMARY ROUTES OF ENTRY	☐Inhalation ☐Skin Absorption	☐Ingestion ☐Not Hazardous	**CARCINOGEN LISTED IN**	☐NTP ☐IARC Monograph	☐OSHA ☐Not Listed
HEALTH HAZARDS	Acute	May cause eye, skin and mucous membrane irritation.			
	Chronic	Prolonged inhalation may cause lung damage.			
Signs and Symptoms of Exposure	Drying and irritation.				
Medical Conditions Generally Aggravated by Exposure	Asthma.				
EMERGENCY FIRST AID PROCEDURES - Seek medical assistance for further treatment, observation and support if necessary.					
Eye Contact	Flush with water for at least 15 minutes.				
Skin Contact	Wash affected area with soap and water.				
Inhalation	Remove affected person to fresh air.				
Ingestion	Drink at least 2 glasses of water.				

Section 6 - Control and Protective Measures

Respiratory Protection (Specify Type)	Use NIOSH approved dust mask or respirator.		
Protective Gloves	Light cotton gloves.	Eye Protection	Safety glasses.
VENTILATION TO BE USED	☐ Local Exhaust	☐Mechanical (General)	☐Special
	☐Other (Specify)		
Other Protective Clothing and Equipment	None.		
Hygienic Work Practices	Avoid raising dust. Avoid contact with skin, eyes and clothing.		

Section 7 - Precautions for Safe Handling and Use/Leak Procedures

Steps to be Taken if Material Is Spilled Or Released	Sweep or vacuum up and place the spilled material in a waste disposal container. Avoid raising dust.
Waste Disposal Methods	Dispose in an approved landfill according to federal, state and local regulations.
Precautions to be Taken In Handling and Storage	Cover promptly to avoid blowing dust. Wash after handling.
Other Precautions and/or Special Hazards	Keep in sealed containers away from moisture. The silica gel will readily adsorb moisture.

*Optional Indicating Silica Gel

MULTISORB
Multisorb Technologies Inc.

MATERIAL SAFETY DATA SHEET

Effective Date March 8, 2005
MSDS Number M163

Section 1 – Product and Company Information

Product Name: **Silica gel, indicating, yellow**

Product Use: Desiccant, absorbent
Grades: Silica gel, indicating
Synonyms: Amorphous silica gel, SiO_2, silicon dioxide (amorphous)

Company; Multisorb Technologies, Inc.
Street Address: 325 Harlem Road
City, State, Zip, Country: Buffalo, NY 14224-1893 USA

Telephone Number: (716) 824 8900 [USA] Monday - Friday (8:00 - 5:00 EDT)
Fax Number: (716) 824 4091 [USA]
Website / E-Mail : multisorb.com

Section 2 – Composition / Information on Ingredients

Component Name	CAS Number	% by Weight
Synthetic amorphous silica gel (SiO_2)	112926-00-8	100
Phenolphthalein	77-09-08	100 ppm

While this material is not classified, this MSDS contains valuable information critical to the safe handling and proper use of this product. This MSDS should be retained and available for employees and other users of this product.

Section 3 – Hazard Identification

Emergency Overview: A yellow bead or granular material that poses little or no immediate hazard. This material is not combustible.

Potential Health Effects:

Eyes: Dust and or product may cause eye discomfort and irritation seen as tearing and reddening.

Skin: The product dust may cause drying of the skin. Silica gel may get hot enough to burn skin when it adsorbs moisture rapidly. Use an excess of water to cool the silica gel.

Ingestion: Material is not toxic and will pass through the body normally.

Inhalation: Slight irritation is possible but none is expected.

Medical Effects Generally Aggravated by Exposure: Respiratory ailments.

Chronic Effects/Carcinogenity: May cause eye, skin and mucous membrane irritation and drying.

Section 4 – First Aid Measures

Eyes: Rinse the eyes well with water while lifting the eye lids. If irritation persists, consult a physician.

Skin: Wash affected area with soap and water.

Ingestion: Ingestion is unlikely, this material will pass through the body normally.

Inhalation: Remove the affected person to fresh air and get medical attention if necessary.

Notes to Physician: Not applicable

Section 5 – Fire Fighting Measures

Flammable Properties: Not flammable

Flash Point: Not applicable **Method:** Not applicable

Flammable Limits: Not flammable

Lower Flammability Limit: Not applicable

Upper Flammability Limit: Not applicable

Autoignition Temperature: Not applicable

Hazardous Combustion Products: Not applicable

Extinguishing Media: Use extinguishing media that is appropriate for the surrounding fire. Silica gel is not combustible.

Fire Fighting Instructions: Not combustible

Unusual Fire and Explosion Hazards: None

Section 6 – Accidental Release Measures

Spill: Sweep or vacuum up and place the spilled material in a waste disposal container. Avoid raising dust. Wash with soap and water after handling.

Section 7 – Handling and Storage

Handling: Avoid raising dust and minimize the contact between worker and the material. Practice good hygienic work practices.

Storage: Store in a cool, dry location. Keep in sealed containers away from moisture. The silica gel will readily adsorb moisture.

Section 8 – Exposure Controls/Personal Protection

Engineering Controls: Use exhaust ventilation to keep the airborne concentrations below the exposure limits.

Respiratory Protection: Use NIOSH approved respirator when the air quality levels exceed the TLV's.

Skin Protection: Light gloves will protect against abrasion and drying of the skin.

Eye Protection: Safety glasses.

Component Name	Exposure Limits		
	OSHA PEL	**ACGIH TLV**	**Other Recommended Limits**
Silica gel	TWA 20 mppcf (80 mg / m^3 % SiO_2)	TWA 10 mg / m^3	NIOSH REL TWA 6 mg / m^3 IDLH 3000 mg / m^3
Phenolphthalein	Not Applicable	Not Applicable	Not Applicable

Section 9 – Physical and Chemical Properties

Appearance: Yellow beads or granules

Odor: None

Physical State: Solid bead

PH: Not applicable

Vapor Pressure: Not applicable

Vapor Density: Not applicable

Boiling Point: 4046° F (2230° C)

Melting Point: 3110° F (1710° C)

Solubility: Insoluble in water

Specific Gravity: 2.1

Section 10 – Stability and Reactivity

Stability: Stable

Conditions to avoid: Moisture and high humidity environments.

Incompatibility: Water, fluorine, oxygen difluoride, chlorine trifluoride

Hazardous Decomposition Products: None

Hazardous Polymerization: Will not occur

Section 11 – Toxicological Information

This product and its components are not listed on the NTP or OSHA Carcinogen lists.

Animal Toxicology Tests for DOT Hazard classification
(Tests Conducted on finely ground silica gel)

1 - hour LC_{50} (rat) > 2 mg / l
48 - hour oral LD_{50} (rat) est. > 31,600 mg / kg
48 - hour dermal LD_{50} (rabbit) est. > 2,000 mg / kg
Considered an ocular irritant

Human Toxicology Silica gel is a synthetic amorphous silica not to be confused with crystalline silica. Epidemiological studies indicate low potential for adverse health effects. In the activated form, silica gel acts as a desiccant and can cause a drying irritation of the mucous membranes and skin in cases of severe exposure. Multisorb Technologies Inc. knows of no medical conditions that are abnormally aggravated by exposure to silica gel. The primary route of entry is inhalation of dust.

Section 12 – Ecological Information

Not known to have any adverse effect on the aquatic environment. Silica gel is insoluble and non-toxic.

Section 13 – Disposal Information

Disposal Information If this product as supplied becomes a waste, it does not meet the criteria of a hazardous waste as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261. Materials of a hazardous nature that contact the product during normal use may be retained on the product. The user of the product must identify the hazards associated with the retained material in order to assess the waste disposal options. Dispose according to federal, state and local regulations.

Section 14 – Transportation Information

U.S. Department of Transportation Shipping Name: Not classified as a hazardous material. Not regulated.

Section 15 – Regulatory Information (Not meant to be all inclusive - selected regulations represented)

TSCA Listed: Yes

DSL/NDSL (Canadian) Listed: Yes

OSHA: TWA 20 mppcf (80 mg / m^3 % SiO_2) for Silica gel

NIOSH: REL TWA 6 mg / m^3 IDLH 3,000 mg / m^3 for silica gel
Animal tests conducted in 1976 - 1978. 18 month exposure at 15 mg / m^3 showed silica deposition in respiratory macrophages and lymph nodes, minimum lung impairment, no silicosis.

ACGIH: TLV - 10 mg / m^3 for Silica gel

DOT: Not classified as a hazardous material.

Section 16 – Other Information

HMIS – Hazardous Materials Identification System

HMIS Rating	
Health	0
Flammability	0
Reactivity	0

0 - minimal hazard, 1 - slight hazard, 2 - moderate hazard, 3 - serious hazard, 4 - severe hazard

This MSDS was prepared by: George E. Mckedy
Senior Applications Development Specialist
Multisorb Technologies, Inc.

This data and recommendations presented in this data sheet concerning the use of our product and the materials contained therein are believed to be correct but does not purport to be all inclusive and shall be used only as a guide. However, the customer should determine the suitability of such materials for his purpose before adopting them on a commercial scale. Since the use of our products is beyond our control, no guarantee, expressed or implied, is made and no responsibility assumed for the use of this material or the results to be obtained therefrom. Information on this form is furnished for the purpose of compliance with Government Health and Safety Regulations and shall not be used for any other purposes. Moreover, the recommendations contained in this data sheet are not to be construed as a license to operate under, or a recommendation to infringe, any existing patents, nor should they be confused with state, municipal or insurance requirements, or with national safety codes.

4150 Flow Logger

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DECLARATION OF CONFORMITY

CE
ISM1-A

Application of Council Directive:	89/336/EEC – The EMC Directive 73/23/EEC – The Low Voltage Directive
Manufacturer's Name:	Isco, Inc.
Manufacturer's Address:	4700 Superior, Lincoln, Nebraska 68504 USA Mailing Address: P.O. Box 82531, Lincoln, NE 68501
Equipment Type/Environment:	Laboratory Equipment for Light Industrial/Commercial Environments
Trade Name/Model No:	4200T Modem
Year of Issue:	2001
Standards to which Conformity is Declared:	EN 55024-1998 EMC Requirements for Information Technology Equipment EN 60950 Safety Requirements for Information Technology Equipment FCC Part 68

Standard	Description	Severity Applied	Performance Criteria
EN61000-4-2	Electrostatic Discharge	Level 2 - 4kV contact discharge Level 3 - 8kV air discharge	B B
EN61000-4-3	Radiated RF Immunity	80 MHz to 1000MHz 80% AM at 1kHz Level 1 – 10V/m	A
EN61000-4-4	Electrical Fast Transient	Level 2 - 2kV on ac lines	B
EN61000-4-5	Surge on AC Lines	2kV common mode, 1kV differential mode	B
EN61000-4-6	Conducted RF on AC lines	150 kHz to 80 MHz, 3V rms, 80% modulated	B
EN61000-4-11	Voltage Dips/Short Interruptions	0.5 cycle, each polarity/100%	B
EN 55022	RF Emissions	Group 1, Class A, Information Technology Equipment	
EN61000-3-2, 3-3	Harmonic, Flicker		

We, the undersigned, hereby declare that the design of the equipment specified above conforms to the above Directive(s) and Standards as of July 5, 2001.

Bill Foster
USA Representative

Isco

Bill Foster
Director of Engineering
Isco, Inc.
4700 Superior Street
Lincoln, Nebraska 68504

Phone: (402) 464-0231
Fax: (402) 464-4543

60-3212-049
Rev.

Michael Teutscher
European Authorized Representative

Isco
STIP

Contact: Dr. Dirk Köppenkastrop
Geschäftsführer Managing Director
STIP ISCO GmbH

Siemensstraße 2
64823 Groß-Umstadt

Telefon: 06078 7 86-82
Telefax: 06078 7 86-88

*Teledyne Isco One Year Limited Factory Service Warranty **

Teledyne Isco warrants covered products against failure due to faulty parts or workmanship for a period of one year (365 days) from their shipping date, or from the date of installation by an authorized Teledyne Isco Service Engineer, as may be appropriate.

During the warranty period, repairs, replacements, and labor shall be provided at no charge. Teledyne Isco's liability is strictly limited to repair and/or replacement, at Teledyne Isco's sole discretion.

Failure of expendable items (e.g., charts, ribbon, tubing, lamps, glassware, seals, filters, fittings, and wetted parts of valves), or from normal wear, accident, misuse, corrosion, or lack of proper maintenance, is not covered. Teledyne Isco assumes no liability for any consequential damages.

This warranty does not cover loss, damage, or defects resulting from transportation between the customer's facility and the repair facility.

Teledyne Isco specifically disclaims any warranty of merchantability or fitness for a particular purpose.

This warranty applies only to products sold under the Teledyne Isco trademark and is made in lieu of any other warranty, written or expressed.

No items may be returned for warranty service without a return authorization number issued from Teledyne Isco.

The warrantor is Teledyne Isco, Inc.
4700 Superior, Lincoln, NE 68504, U.S.A.

*** This warranty applies to the USA and countries where Teledyne Isco Inc. does not have an authorized dealer. Custo mers in countries outside the USA, where Teledyne Isco has an authorized dealer, should contact their Teledyne Is co dealer for warranty service.**

In the event of instrument problems, always contact the Teledyne Isco Service Department, as problems can often be diagnosed and corrected without requiring an on-site visit. In the U.S.A., contact Teledyne Isco Service at the numbers listed below. International customers should contact their local Teledyne Isco agent or Teledyne Isco International Customer Service.

Return Authorization

A return authorization number must be issued prior to shipping. Following authorization, Teledyne Isco will pay for surface transportation (excluding packing/crating) both ways for 30 days from the beginning of the warranty period. After 30 days, expense for warranty shipments will be the responsibility of the customer.

Shipping Address: Teledyne Isco, Inc. - Attention Repair Service
4700 Superior Street
Lincoln NE 68504 USA

Mailing address: Teledyne Isco, Inc.
PO Box 82531
Lincoln NE 68501 USA

Phone: Technical Support (800)775-2965 (lab instruments)
(866)298-6174 (samplers & flow meters)
Sales & General Information: (800)228-4373 (USA & Canada)

Fax: (402) 465-3001

Email: iscoservice@teledyne.com **Web site:** www.isco.com

March 17, 2009 P/N 60-1002-040 Rev D

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A Teledyne Technologies Company